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Black fungus gnats (Diptera: Sciaridae) found in association with cultivated plants and mushrooms in Australia, with notes on cosmopolitan pest species and biosecurity interceptions

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Abstract

Male sciarids collected in Australia from inside post-entry quarantine and domestic greenhouses and from vegetable gardens and various plants, were slide mounted and identified. Specimens intercepted during on-arrival biosecurity inspections of imported nursery stock plants were also examined, and the New South Wales Department of Primary Industries collection of slide-mounted Sciaridae was reviewed. Plant and mushroom pest species that are present in Australia are *Bradysia impatiens* (Johannsen), *B. ocellaris* (Comstock), *Lycoriella agraria* (Felt), *L. ingenua* (Dufour) = *Sciara womersleyi* Séguy, 1940 **syn. n.**, *L. sativae* (Johannsen) = *Sciara auberti* Séguy, 1940 **syn. n.**, *Sciara jeanneli* Séguy, 1940 **syn. n.**, *Sciara solispina* Hardy, 1956 **syn. n.**, and *Cosmosciara hartii* (Johannsen, 1912) **comb. n.** = *Plastosciara perniciosa* Edwards, 1922 **syn. n.** The last species is a new record for Australia. *Bradysia tilicola* (Loew) and *Pnyxia scabiei* (Hopkins) are potential pest species, but they have not been reported yet from Australia. An identification key to enable separation of the pest species is provided. Species with uncertain connections to plant and mushroom cultures are *B. pallipes* (Fabricius), *B. strenua* (Winnertz, 1867) = *B. watsoni* Colless, 1962 **syn. n.**, *Corynoptera concinna* (Winnertz), (all three species are new records for the Australian mainland) and *Hyperlasion aliens* Mohrig (a new record for Tasmania). *Bradysia spatitergum* (Hardy) and *Scatopsciara atomaria* (Zetterstedt) were intercepted during the on-arrival biosecurity inspections of live plants imported from China and Canada respectively. Both species are widespread overseas but are not known to occur in Australia.

Key words: Biosecurity, fungi, glasshouse, greenhouse, Hawaii, identification, key, Kerguelen Islands, Macquarie Island, new combination, new synonyms, nurseries, new species, quarantine, pest, sciarid taxonomy, zoogeography

Introduction

In Australia, the Sciaridae, sometimes called black fungus gnats, are rather poorly known, even though they are one of the most abundant families of Diptera in forest habitats (Bickel 2009). Exceptions include a few economic pests of the cultivated mushroom *Agaricus bisporus* (Lange) Imbach (Bugledich *et al.* 2011), the male sciarid types described by F.A.A. Skuse (Skuse 1888; Skuse 1890), reviewed by Broadley *et al.* (2016) and some Sciaridae species that we described from Queensland (Mohrig *et al*. 2017). However, little is known about the identity and distribution of species associated with cultivated plants, and the Australian sciarid fauna as a whole remains mostly unstudied. In the course of his work the first author found that this lack of information was an impediment to the determination of the pest status of sciarids intercepted by biosecurity officers in imported goods, and in post-entry quarantine and domestic greenhouses and nurseries in Australia.

About 10 species of Sciaridae are known to be major economic pests (Mohrig *et al.* 2013) because the primarily phytosaprophagous larvae also feed on living plants, damaging roots and sometimes stems and leaves of cultivated plants and cuttings (Hungerford 1916; Hussey *et al.* 1969; Mead 1978; Han *et al.* 2015). Young seedlings are particularly susceptible (Parr *et al.* 1954; Cloyd 2015) and these may be eaten entirely (Springer

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1995a). Larvae of the mushroom pest species feed on the developing mycelium in the compost and casing layers, destroying sporophore primordia and damaging more mature sporophores by tunneling (Shamshad 2010). Sciarids are often found in close association with potted plants (Chittenden 1901; Hungerford 1916; Harris *et al.* 1996) and are common inhabitants of greenhouses and nurseries (Chittenden 1901; Edwards & Williams 1916; Parr *et al.* 1954; Gerbatchevskaya 1963; Stacey 1969; Dennis 1978; Mead 1978; Sasakawa & Akamatsu 1978; Keates *et al.* 1989), although crop and pasture plants in open fields may also be attacked (Hungerford 1916; Springer 1995b).

In greenhouses, adult black fungus gnats can often be observed hovering near plants and running rapidly over pots and the growing medium contained within. Favourable conditions in the confines of a greenhouse, particularly excessive watering, can lead to a rapid increase in sciarid numbers and the proliferation of fungi (Cloyd 2015). This presents a hygiene problem because both the larvae (Hurley *et al.* 2007; James *et al.* 1995) and adults (El-Hamalawi & Stanghellini 2005; El-Hamalawi 2008; James *et al.* 1994; James *et al.* 1995; Kalb & Millar 1986; Keates *et al.* 1989; Elmer 2008; Gillespie & Menzies 2008; Shamshad *et al.* 2009) are vectors of fungal pathogens. Furthermore, direct feeding by larvae may predispose plants to further attack by soil-borne plant pathogens (Cloyd 2015). This combination of feeding damage and subsequent infection by plant diseases can lead to stunting of growth and eventual plant death (Cloyd 2015).

Larvae can inadvertently be transported to new areas via infested potting mix—even bagged soilless media and rooted plant plugs have been shown to act as pathways for sciarid movement (Cloyd & Zaborski 2003). Yellow sticky traps are often used to monitor adult sciarids and to help reduce overall numbers. In 2013 Nursery & Garden Industry Australia published a management plan for sciarids in production nurseries (NGIA 2013).

The first published account of sciarid pests in Australia that we could find was in relation to mushroom flies (*Sciara* sp.) (Shanahan 1948). Detailed research started in the mid 1970's on aspects of the taxonomy, biology, ecology and control of sciarid pests of mushrooms, at the Biological and Chemical Research Institute (BCRI) of the New South Wales Department of Agriculture, Rydalmere (Loudon 1978; Clift 1979; Clift & Larsson 1984). The taxonomic information presented to date, however, for the mushroom pests in particular has been rather chaotic. Loudon (1978) described *Lycoriella agarici* as a new species and the major pest of protected mushroom cultivation in New South Wales. He noted an additional two mushroom pest species from Victoria—*L. agraria* (Felt) and *L. multiseta* (Felt). In their review of mushroom pests in Australia Greenslade & Clift (2004) remarked that *L. agraria* may no longer be present in Australia and that *L. multiseta* is not a very serious pest and both may have been misidentified. *Lycoriella multiseta* was later synonymized with *L. agraria* by Mohrig *et al.* (2013). Clift (1979) reported a fourth species, *L. solani* (Winnertz), from a mushroom farm in New South Wales. *Lycoriella agarici* was misidentified as *L. auripila* (Winnertz) sensu Tuomikoski. The description of *L. auripila* in Freeman (1983) actually refers to *L. castanescens* (Lengersdorf) [Clift & Larsson 1984; Freeman 1987; Greenslade & Clift 2004]. *Lycoriella solani* was synonymised with *L. mali* (Fitch) [Clift & Larsson 1984; Freeman 1987]. *Lycoriella castanescens* was synonymised with *L. sativae* (Johannsen) [Mohrig *et al.* 2013] and *Lycoriella mali* was synonymised with *L. ingenua* (Dufour) by Menzel & Mohrig (2000). *Bradysia impatiens* (Johannsen) [= *B. difformis* (Frey)] was recorded in Australia for the first time by Greenslade & Clift (2004) from a mushroom farm and pot plant in Tasmania. *Bradysia ocellaris* (Comstock) first appeared in a checklist of insects of Tasmania (Semmens *et al.* 1992) under the synonym *B. tritici* (Coquillett), based on specimens collected in 1992 from a glasshouse in New Town, Hobart (Greenslade & Clift 2004). *Bradysia ocellaris* was subsequently recorded from Queensland (Menzel *et al.* 2003). *Bradysia ocellaris* and *L. ingenua* are now the major mushroom pests in Australia according to Shamshad (2010).

Sciarid flies collected from some greenhouses, including post-entry quarantine (PEQ) and non-quarantine (domestic) nurseries, vegetable gardens, damaged plants and from inside houses in association with pot plants are here reviewed, to help better understand the identity, distribution and pest status of these flies in Australia. Specimens intercepted during on-arrival biosecurity inspections of imported nursery stock plants are also identified. Furthermore, the New South Wales Department of Primary Industries collection of slide mounted Sciaridae—the largest collection in Australia (APPD 2015)—has been reviewed. This includes the BCRI material collected from crop plants, plant products and mushrooms by Loudon, Clift and others in the 1970's and 1980's.

An illustrated key to the cosmopolitan pest species of Sciaridae is provided which will enable those working with cultivated plants and mushrooms in particular to make faster, more accurate identifications. The key includes species that are present in Australia as well as some pests that could be intercepted by biosecurity officers during on-arrival inspections of nursery stock, plant products and edible fungi imported from overseas.

Materials and methods

Sciaridae adults were either collected by hand with an aspirator or in yellow pan traps and stored in 80% ethanol prior to slide mounting. The names of the plants that were being held in greenhouses at the time of collection were noted.

The slide mounting procedure was undertaken using a dissecting microscope in a fume hood. Male specimens were transferred to a glass cavity block containing 96% ethanol and left to sit for a minimum of 10 min at room temperature. Then the specimens were transferred to a separate cavity block containing beechwood creosote and left for at least 30 min. The body of each specimen was transferred to the middle of a microscope slide using a needle and the hypopygium was separated from the body using a fine blade. A small drop of Canada balsam ca. 3 mm in diameter was placed on one side of the slide and the hypopygium was immersed in this droplet, positioned ventral side up and a 6 mm cover slip carefully lowered over it. The body was positioned laterally in the middle of the slide with a needle so that the head, antennae, palps, legs and wings were visible, then it was immersed in a larger drop of Canada balsam ca. 5 mm in diameter. A cover slip 10 mm in diameter was lowered on top. The slide was then labelled and put in an incubator set at 50° C for at least 4 weeks.

Illustrations with respective size measurements were created using digital images taken with a Keyence VHX-2000 digital microscope and stacking software. Photographs were modified using Adobe Photoshop software. Prints were then enhanced by hand drawing over the photos to reveal features that may ordinarily have been missed using photos alone. After final scanning coupled with touch-ups using Photoshop, images were finalized for publication.

The terminology used herein follows Menzel & Mohrig (1997), Menzel & Mohrig (2000), Mohrig *et al*. (2013) and Broadley *et al*. (2016).

The collection details for each species are listed first by state or territory on the Australian mainland, from Queensland clockwise to the Northern Territory.

Abbreviations: l/w-index = length/width of the basal node of the 4^{th} flagellomere; c/w = ratio of C (costal vein) and w (distance between apex of R_{4+5} and apex of M_1); x/y = wing vein bM/wing vein r-m.

Museums:

ANIC	Australian National Insect Collection, CSIRO, Canberra, Australia
ASCU	Agricultural Scientific Collections Unit, New South Wales Department of Primary Industries, Orange, New South Wales, Australia
BIOUG	Centre for Biodiversity Genomics, University of Guelph, Ontario, Canada
PABM	Private Collection of Adam Broadley, Melbourne, Australia
PWMP	Private Collection of Werner Mohrig, Puddemin, Germany
SAMA	South Australian Museum, Adelaide, South Australia, Australia
SDEI	Senckenberg German Entomological Institute Müncheberg, (Senckenberg Deutsches Entomologisches Institut), Müncheberg, Germany
TAIC	Tasmanian Agricultural Insect Collection, Department of Primary Industries, Parks, Water and Environment, New Town, Tasmania, Australia.
VAIC	Victorian Agricultural Insect Collection, Agriculture Victoria, Bundoora, Victoria, Australia

Results

I. Species associated with plants or fungi

In the Holarctic region eight sciarid species are common pests, feeding on living plants and fungi in nurseries, greenhouses, mushroom farms and homes with plant pots. These are *Bradysia impatiens* (Johannsen), *B. ocellaris* (Comstock), *B. tilicola* (Loew), *Cosmosciara hartii* (Johannsen), *Lycoriella agraria* (Felt), *L. ingenua* (Dufour), *L. sativae* (Johannsen), and *Pnyxia scabiei* (Hopkins). Although most of these species are very common, it should be

noted that the damage that they cause may not always be of economic importance, particularly with respect to pot plants in houses. *Cosmosciara hartii* and *P. scabiei* are not generally encountered as frequently as the others, but these too can build up into large numbers in nurseries and greenhouses. The other six species are moderately thermophilic; in the Holarctic region they maintain more or less large populations in open landscapes (natural biotopes, parks, vegetable gardens and cultivated fields) in southern countries and in exposed southern-facing areas.

It is somewhat surprising that in a country like Australia, which has a rich sciarid fauna, no native species have yet been found to exploit the "greenhouse" as a new food resource. On the other hand, in the Palaearctic region, where more than 800 sciarid species are known, only eight are known to be common and widespread pests that feed on living plants in greenhouses and in houses (i.e. on potted plants), or on cultivated fungi (ca. 1% of the fauna). These species, which are permanently associated with cultivated plants and fungi, belong to 4 genera: *Bradysia* (3), *Cosmosciara* (1), *Lycoriella* (3) and *Pnyxia* (1).

A number of other sciarids have been reported as pests in the literature but as the reports are comparatively few in number we will only briefly mention three species here: *Bradysia cellarum* Frey, a pest of onions in China (Ye *et al.* 2017), *Bradysia procera* (Winnertz), a pest of ginseng in South Korea (Shin *et al*. 2008) and *Bradysia nomica* Mohrig & Röschmann, a crop pest in Spain (Rodríguez-Rodríguez *et al*. 2005).

Key to cosmopolitan pest species

1. Specimens in both sexes maggot-like, micropterous .... *Cosmosciara hartii* (Johannsen), morphotype II (Fig. 9 A, C–D)
- Specimens winged, micropterous or apterous, never maggot-like 2
2. Apex of fore tibia (tibial organ) with a comb-like row of bristles...*Bradysia* Winnertz (Figs 1, 3) 3
- Tibial organ of other shape 5
3. Both x and y with macrotrichia (Fig. 10 E). .... *B. tilicola* (Loew), (Fig. 10)
- x and y without macrotrichia. 4
4. Gonostylus at the apex with a short claw-like tooth and a dense group of subapical spines; basal flagellomeres uniformly brown, with a smooth surface; thorax brown .... *B. impatiens* (Johannsen), (Figs 1, 2)
- Gonostylus with an apical tooth and 4 isolated subapical spines in the distal third (two within dense apical hairs); basal flagellomeres mostly yellowish, with a rough surface .... *B. ocellaris* (Comstock), (Fig. 3)
5. Tibial organ indifferent, not bordered; palpi shortened, 1–2-segmented; gonostylus without whiplash hair...*Cosmosciara* Frey; *Pnyxia* Johannsen, ... 9
- Tibial organ with a horseshoe-shaped border (e.g. Fig. 4 D); palpi 3-segmented, basal segment with a deep and dark sensory pit; gonostylus with a long whiplash hair near the middle of the inner side. .... *Lycoriella* Frey...7
7. Base of hypopygium with 4–8 isolated bristles on the intergonocoxal membrane; the inner side of gonostylus with 4–6 spines above the whiplash hair. .... *L. sativae* (Johannsen), (Fig. 6)
- Base of hypopygium with a haired intergonocoxal lobe; the inner side of gonocoxites with 3 or more than 4 spines above the whiplash hair 8
8. Gonostylus long and continuously pointed toward the apex; the inner side with 6–8 short spines. Lobe on base of genitalia high and tongue-like, with pale-brown bristles. .... *L. ingenua* (Dufour), (Fig. 5)
- Gonostylus shorter, the inner side with 4–6 long robust spines above the whiplash hair. Lobe on base of genitalia wide, with dark spine-like bristles .... *L. agraria* (Felt), (Fig. 4)
9. Gonostylus with a tooth, located somewhat subapically; palpus 1-segmented (sometimes with a small rudimentary 2nd segment), the basal segment without a deepened sensory area; flagellomeres short, l/w index of 1.2; wings of normal size .... *Cosmosciara hartii* (Johannsen), morphotype I (Figs 7, 8, 9 B)
- Gonostylus without tooth; palpus 1-segmented, with a large, apical sensory pit; flagellomeres long, with long necks, l/w index at least 2.2; wings brachypterous in males and absent in females (apterous) .... *Pnyxia scabiei* (Hopkins), (Figs 11, 12)

I. 1. Cosmopolitan pest species in Australia

Genus *Bradysia* Winnertz, 1867

When mounted on slides it is easy to identify specimens as belonging to the genus *Bradysia*. The main character is the shape of the tibial organ on the fore tibia, consisting of a comb-like row of bristles on a united base, distinctly separated from the ground hair of the tibia. Additional characters are a 3-segmented palpus with at least 2 bristles on the basal segment, bare posterior wing veins and a rather long R_1 (different from *Scatopsciara*). The genus is

distributed worldwide in all zoogeographic zones with plant growth and is likely to be the most species-rich sciarid genus of all.

Bradysia impatiens (Johannsen, 1912)

(Figs 1 A–E, 2 A–C)

Sciara impatiens Johannsen, 1912 [Johannsen (1912): 136, figs 137, 252].

Common synonyms: *Bradysia difformis* (Frey, 1948); *Bradysia paupera* Tuomikoski, 1960; *Bradysia agrestis* Sasakawa, 1978.

Literature: Frey (1948): 61, 83, fig. 98 (as *Bradysia* (*Chaetosciara*) *tristicula* var. *difformis*); Tuomikoski (1960): 130, 134, figs 28 c, 31 l, 32 b (as *Bradysia paupera*); Steffan (1973a): 355; Steffan (1974): 43–44; Kühne *et al*. (1994): 34–45, figs 26–41 (as *Bradysia paupera*); Menzel & Mohrig (2000): 146, figs 129–131; Menzel *et al*. (2003): 449, figs 1–10 (both as *Bradysia difformis*); Mohrig *et al*. (2013): 162–163.

Material studied. **QUEENSLAND**: 2 males, hand collection, 4.xii. 2013, in PEQ greenhouse with bromeliads, Canvey Road, Ferry Grove, #3B, leg. M. Watts; 3 males, hand collection, 22.x.2014, in greenhouse with tomato and banana plants, Ecosciences Precinct, Dutton Park, #24B, leg. D. Beasley; 8 males, hand collection, 11.xi.2014, Geldart Road, Chandler, in greenhouses with *Selaginella*, *Hydrangea*, *Euphorbia*, *Sutera cordata*, *Fittonia*, African violets, #38 & 42B, leg. A. Manners; 4 males, hand collection, 12.xi.2014, in greenhouse with Azalea, *Ixora*, *Mandevilla* plants, Orchard Road, Redland Bay, #39A, leg. A. Manners; 3 males, 11.xi.2014, in greenhouse with *Gahnia*, *Banksia*, *Eucalyptus*, *Lomandra* and *Acacia*, Sunnydene Road, Capalba, #45B, leg. A. Manners; 3 males, hand collection, 11.xi.2014, in greenhouse with *Gerbera*, *Eustoma*, passionfruit and *Chrysanthemum*, Dundas Street, Ormiston, #46, leg. A. Manners; 2 males, hand collection, 5.ii.2014, in greenhouse with avocado, citrus, hoop pine and passionfruit plants, Ecosciences Precinct, Dutton Park, #43B, leg. A. Manners; 3 males, 11.xi.2014, in greenhouse with *Liriope*, *Hardenbergia*, *Lophostemon*, *Eustrephus* and *Schoenoplectus* plants, New Cleveland Road, Gumdale, #50, leg. A. Manners; 2 males, 12.xi.2014, hand collection, in greenhouse with *Banksia*, *Hymenocallis*, *Harpullia*, *Dracaena* and *Lomandra* plants, Mt Cotton Road, Burbank, #52, leg. A. Manners; 2 males, 12.xi.2014, hand collection, in greenhouse with *Anthurium*, *Hoya* and *Bougainvillea* plants, German Church Road, Redland Bay, #54B, leg. A. Manners; 1 male, 12.xi.2014, hand collection, in greenhouse with *Callistemon*, *Grevillea*, *Westringia* and *Agapanthus* plants, Worthing Road, Victoria Point, #55, leg. A. Manners; 3 males, hand collection, 16.i.2015, in greenhouse with *Mentha requienii* plants, Burow Road, Waterford West, #79, leg. A. Manners.

NEW SOUTH WALES: 2 males, 22.ii.2008, Sydney, biosecurity intercept (Bottle 130465), *Pelargonium* plants ex Ethiopia, leg. C. Gillian; 2 males, 11.vi.2009, Sydney, biosecurity intercept (Bottle 140909), *Euphorbia* plants ex Germany, leg. E. Nikolic; 2 males, 22.iii.2010, Sydney, biosecurity intercept (Bottle 159764), *Hemerocallis* plants ex USA, leg. M. Coleman; 1 male, 27.xi.2007, Sydney, biosecurity intercept (Bottle 81011), decaying *Plumeria* plant ex USA, leg. D. Mercado-Escueta; 3 males, 22.x.2013, Sydney, biosecurity intercept (Bottle 205856), *Stachys byzantina* plants ex Netherlands, leg. M. Brinkworth (all in PABM); 2 males, 13.i.1978, Rydalmere, ex lab culture, ASCT00053399-53400, leg. A.D. Clift; 1 male, 23.v.1978, Parramatta, ASCT00053414, "in numbers around compost outside mushroom farm", leg. A.D. Clift; 2 males, 6.vi.1978, Alstonville, ASCT00053412 & ASCT00053413, "pot plants", leg. B.J. Loudon; 1 male, xii.1979, Port Macquarie, Branch's Nursery, ASCT00053411, "larvae attacking Maidenhair fern roots", unknown collector; 3 males, 21.iv.1980, Yanco, ASCT00054860/ 54848/ 54844, "attacking Lucerne seedlings in glasshouse", unknown collector; 4 males, 17.v.1977, Rydalmere, ASCT00054850/54853/54857/54859, "in pot plant", unknown collector (all in ASCU); 3 males, 4.iii.2014, PEQ greenhouse with cacti and succulents, Cowlong Road, Mcleans Ridge, #8, leg. V. Brake and C. Marston; 2 males, 8.xi.2013, PEQ glasshouse with gerberas, Doyalson North, #23, leg. P. Jennings; 1 male, 17.vi.2008, Sydney, biosecurity intercept (Bottle 131174), bromeliad plants ex Netherlands, leg. C. Gillian (all in PABM); 1 male, 13.i.1978, ex lab culture, Rydalmere, ASCT00054866, leg. A.D. Clift (ASCU); 3 males, 17.vi.2014, hand collection, in greenhouse with *Leucanthemum*, *Clivea*, lavender, *Agapanthus*, *Buddleia*, passionfruit and daisy, Arcadia Road, Arcadia, #51, leg. A. Manners (PABM).

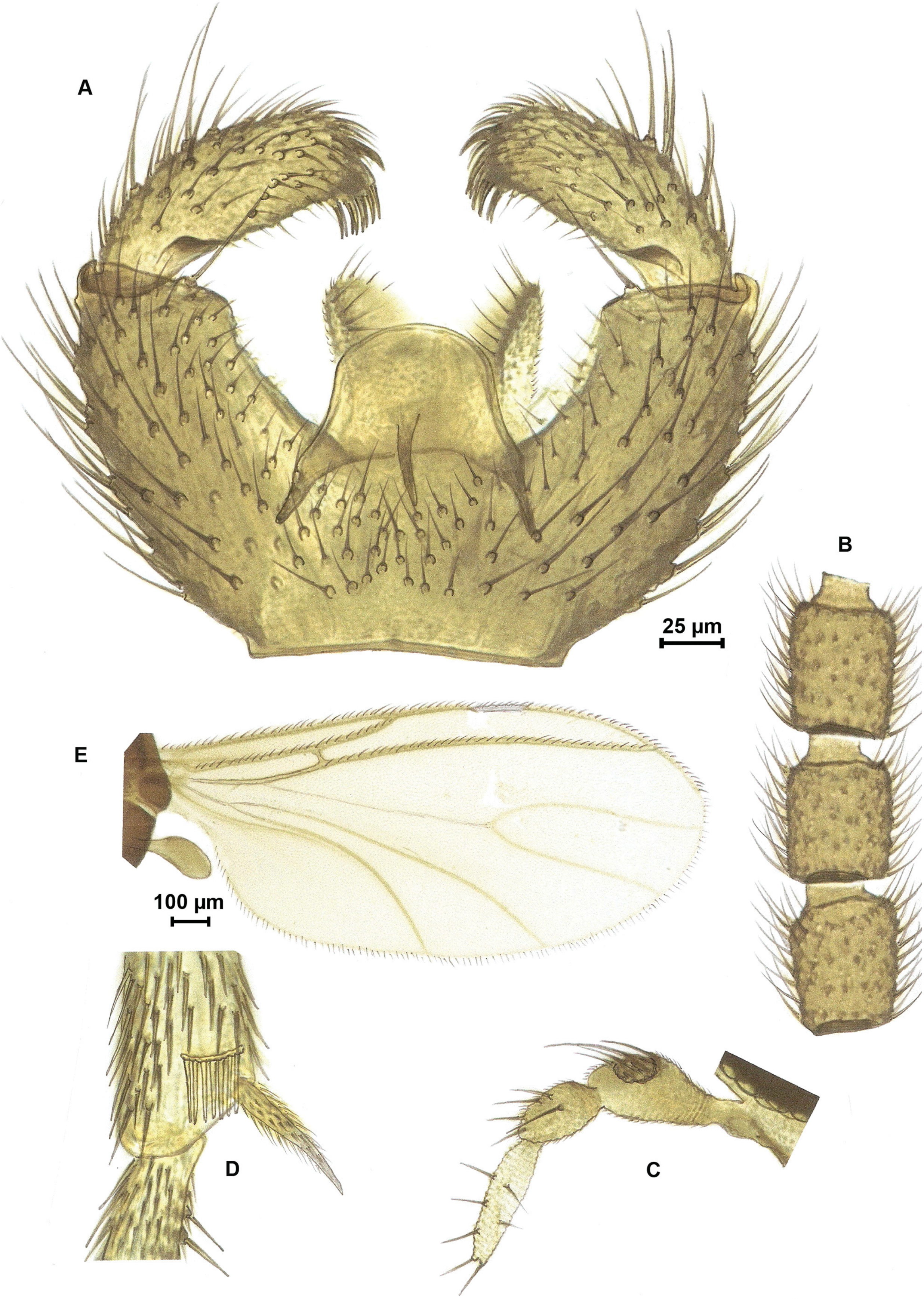

FIGURE 1. *Bradysia impatiens* (Johannsen, 1912). Form A (typical pest specimen). A. Hypopygium. B. Flagellomeres 3–5. C. Palpus. D. Fore tibia. E. Wing.

AUSTRALIAN CAPITAL TERRITORY: 3 males, v.1981, Canberra, CSIRO, ASCT00053406/ 53407/ 53409, "ex pot plants", leg. D.H. Colless; 2 males, 8.v.1963, Canberra, ASCT00053408/54863, "ex pots, plants & gardens", leg. D.H. Colless; 3 males, ix.1968, Canberra, CSIRO Black Mountain, ASCT00053404/53405/54862, "seedlings in glasshouse pots", leg. D. Johns (all in ASCU); 3 males, hand collection, 6.xii. 2013, Canberra, CSIRO, Black Mountain, #2, PEQ rearing room for dung beetles, leg. P. Gleeson and B. Boyd; 1 male, 4.xi.2014, in PEQ glasshouse with cotton, CSIRO Black Mountain, #19A, leg. L. Apps (all in PABM).

VICTORIA: 1 male, 25.ix.2014, biosecurity intercept, Melbourne (Bottle 237624), *Dracaena* plants ex China, leg. M. Mazumder; 3 males, 12.ii.2014, biosecurity intercept, Melbourne (Bottle 224519), *Dracaena* plants ex China, leg. V. Garzarella & A. Czelusta; 2 males, 1.xii.2014, biosecurity intercept, Melbourne (Bottle 224666), *Phalaenopsis* plants ex Taiwan, leg. E. Weeks; 1 male, 12.iii.2014, biosecurity intercept, Melbourne (Bottle 226093), *Phalaenopsis* plants ex Taiwan, leg. S. James; 3 males, 10.xi.2014, biosecurity intercept, Melbourne (Bottle 246278), *Phalaenopsis* plants ex Taiwan, leg. V. Garzarella & A. Czelusta; 4 males, 21.vii.2014, biosecurity intercept, Melbourne (Bottle 224721), *Phalaenopsis* plants ex Taiwan, leg. R. Protacio; 2 males, 20.x.2014, biosecurity intercept, Melbourne (Bottle 246906), *Phalaenopsis* plants ex Taiwan, leg. W. Houston; 3 males, 9.v.2014, biosecurity intercept, Melbourne (Bottle 227591), *Phalaenopsis* orchids ex Taiwan, leg. A. Kosmer; 2 males, 5.i.2015, biosecurity intercept, Melbourne (Bottle 246858), *Phalaenopsis* orchids ex Taiwan, #56, leg. T. Lee & R. Skipper; 1 male, 10.xi.2014, biosecurity intercept, Melbourne, (Bottle 246278), *Phalaenopsis* plants ex Taiwan, leg. V. Gazarella & A. Czelusta (all in PABM); 1 male, xi.2015, yellow pan trap in vegetable garden, Twin River Drive, South Morang, # 86, leg. A. Broadley (PWMP); 3 males, 5.xii.2013, hand collection, in PEQ greenhouse, Keysborough, #9, leg. R. Skipper; 3 males, 23.x.2013, hand collection, in PEQ glasshouses with strawberry, stonefruit and potato plants, Knoxfield, #17B, leg. A. Broadley and L. Sullivan; 1 male, 21.x.2014, hand collection, in PEQ glasshouse with *Iris*, Lilydale, #20, leg. R. Skipper; 2 males, 30.x.2013, hand collection, in PEQ glasshouse with *Ficus*, *Tillandsia*, *Sansevieria*, *Dracaena* and bromeliads, Heatherton Road, Narre Warren, #22, leg. R. Skipper (all in PABM); 3 males, hand collection, 4.ix.2001, Somerville, emerged from potting mix under flax plants, #26 (VAIC73176), leg. M. Malipatil (VAIC); 2 males, 1.vi.1999, Officer, Victoria, on decaying roots of cuttings, hand collection, #29 (VAIC73181), unknown collector (VAIC); 4 males, 18.xi.2014, yellow pans in seed houses, Royal Melbourne Botanic Gardens, #37A, leg. D. Robbins; 3 males, 19.vi.2014, hand collection, in greenhouse with *Impatiens*, *Fuchsia*, *Cyclamen*, parsley, tomato and basil plants, Perry Road, Keysborough, #47, leg. A. Manners; 2 males, 19.vi.2014, hand collection, in greenhouse with *Sansevieria*, sage, various herbs and vegetables, Old Dandenong Road, Heatherton, #48B, leg. A. Manners (all in PABM).

SOUTH AUSTRALIA: 3 males, hand collection, 22.xi.2013, Waite Institute (SARDI), in glasshouse with cabbage, #6, leg. N. Luke (PABM).

WESTERN AUSTRALIA: 3 males, hand collection, 9.xii.2013, in PEQ greenhouse with *Phalaenopsis* orchids, Oldbury, #10A, leg. J. Cruttenden and S. Boud; 1 male, hand collection, 1.v.2014, in greenhouse with *Orthrosanthus laxus*, Bingham Road, Bullsbrook, #40B, leg. A. Manners; 3 males, hand collection, 1.v.2014, in greenhouse with *Grevillea* and *Gardenia* plants, Bahen Road, Hacketts Gully, #41A, leg. A. Manners; 4 males, hand collection, 26.vii.2012, infesting Chia stems, Kununurra, #76 (LH1098), leg. L. Halling (all in PABM).

NORTHERN TERRITORY: 1 male, yellow pan, 3.ii.2015, in propagation shade house with *Curcuma*, jackfruit and figs, Makagon Road, Darwin, #85B, leg. M. Finlay-Doney (PABM).

TASMANIA: 3 males, hand collection, 31.x.2013, in glasshouse with sunflowers in peat mix, New Town Research Labs, #14A, leg. G. Anderson; 2 males, yellow pan in glasshouse with *Hebe* and barley, 4.xi.2013, Westbury Road, Prospect, #4, leg. G. Westmore; 1 male, 30.x.2013, Tasmania, Kingston, glasshouse with Peony roses, barley, #16, hand collection, leg. J. Davies and G. Anderson; 2 males, 20.xi.2014, hand collection, in Glasshouse 3 with *Begonia* plants, Royal Tasmanian Botanical Gardens, Queens Domain, Hobart, #78B, leg. N. Tapson (all in PABM).

NORFOLK ISLAND: 6 males, hand collection, 1.xii.2014, on plant pots in shade house, #30 (RAB013), leg. A. Broadley; 4 males, yellow pans, 1.xii.2014, in shade house with native plants, #31 (RAB005a), leg. A. Broadley (all in ANIC).

Form B: 2 males, 30.x.2013, Tasmania, Kingston, glasshouse with Peony roses, barley, hand collection, #16, leg. J. Davies and G. Anderson (PWMP); 1 male, 4.xi.2013, Tasmania, glasshouse with *Hebe*, barley, yellow pan, #4, leg. G. Westmore (TAIC); 2 males, 21.x.2014, Lilydale, Victoria, in PEQ greenhouse with *Iris* plants (Bottle 246807), #20, leg. R. Skipper (PABM); 1 male, 1.vi.1999, Victoria, Officer, on decaying roots of cuttings, hand

collection, leg. unknown (VAIC); 1 male, Victoria, Twin River Drive, South Morang, #86, xi. 2015, yellow pan trap in vegetable garden, leg. A. Broadley (PABM); 1 male, 19.vi.2014, hand collection, in greenhouse with *Sansevieria*, sage, various herbs and vegetables, Victoria, Old Dandenong Road, Heatherton, #48B, leg. A. Manners (PABM); 1 male, 4.xi.2014, in PEQ glasshouse with cotton, CSIRO, Australian Capital Territory, Black Mountain, #19A, leg. L. Apps (PABM); 1 male, 22.ii.2008, New South Wales, Sydney, biosecurity intercept (Bottle 130465), in consignment of *Pelargonium* plants ex Ethiopia, leg. C. Gillian (PABM).

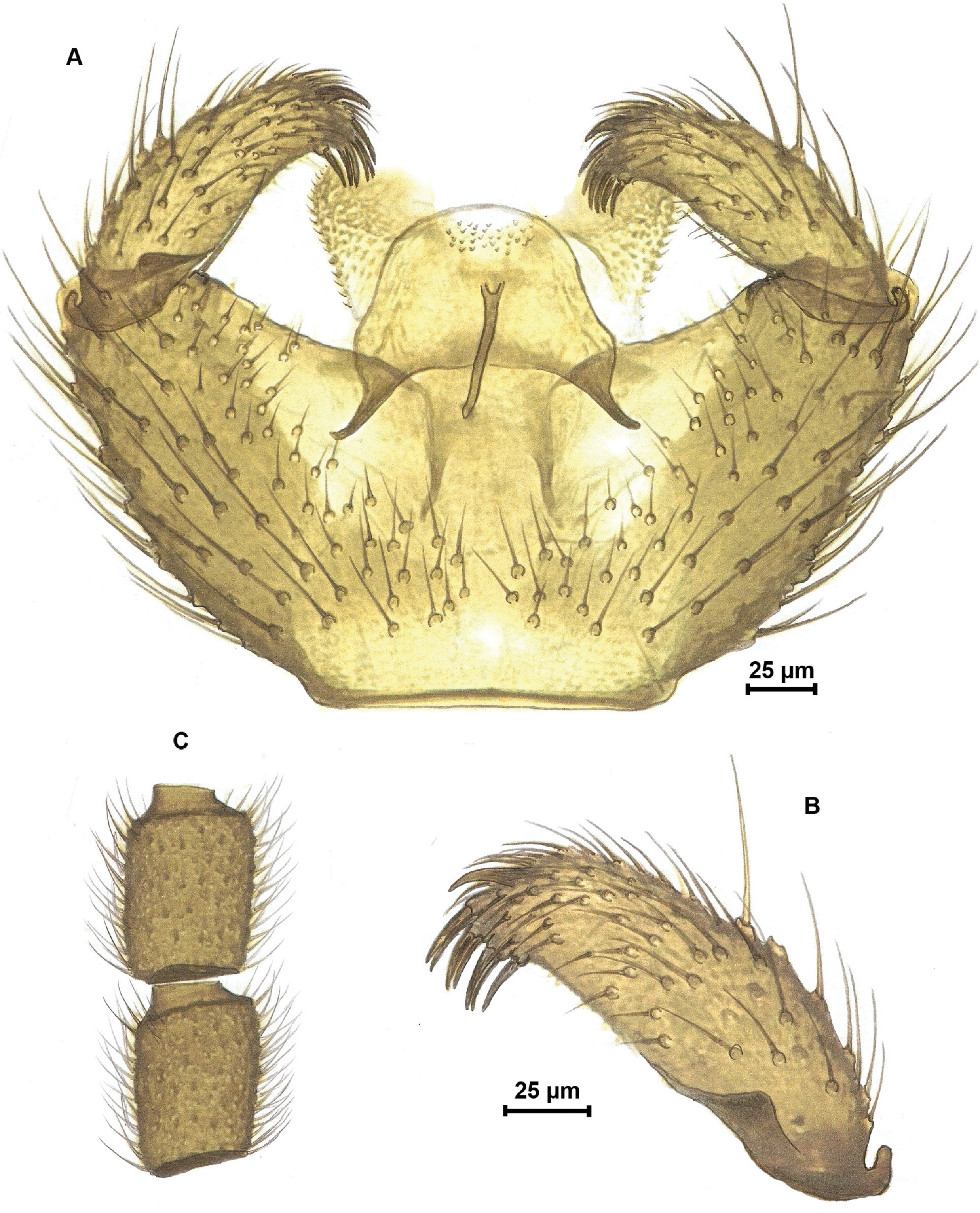

FIGURE 2. *Bradysia impatiens* (Johannsen, 1912). Form B. (specimen from Kingston, Tasmania, glasshouse). A. Hypopygium. B. Gonostylus. C. Flagellomeres 3–4.

Bradysia impatiens was described after it was bred from larvae, found in soil adhering to roots of an *Impatiens* species, in Tompkins Co., Ithaca, USA (Johannsen 1912). It is cosmopolitan in distribution and common in greenhouses and plant nurseries. The larvae feed on roots of different crops such as cucumbers, soybeans, peas, beans, lettuce, etc. The species is found in open landscapes as well. The larvae are phytophagous, phytosaprophagous and perhaps mycetophagous, living in rotting plant material in the soil, in compost and in mouse holes. The species belongs to the *Bradysia tilicola* species group (Menzel & Mohrig 2000).

Diagnostic remarks. The species is characterized by a deep sensory pit on the basal palp segment, very short and uniform brown flagellomeres (l/w index of nearly 1.0), and a rather compact gonostylus with a short claw-like apical tooth amongst 6–8 dense subapical spines. The gonostylus is sometimes slender (form B) and the flagellomeres vary between l/w indexes of 1.0–1.4 [this variability was reported by Steffan (1974) as well].

Economic importance. *Bradysia impatiens* is an important pest of a variety of crops in protected environments such as greenhouses. Mushrooms may be attacked as well. Harris *et al.* (1996) conducted a literature review of the crop plants that have been reported as being damaged by this species: Christmas cactus, marigolds, peperomia, pine, alfalfa, bean, carrot and cucumber. It has also been reported damaging *Agaricus blazei* and *A. bisporus* mushrooms in Brazil (Menzel *et al.* 2003), edible fungi in China (Shen 2009), potted lily and cucumbers in greenhouses in Japan (Sasakawa and Akamatsu, 1978) and *Phalaenopsis* orchid seedlings in greenhouses in Guangdong, China (Han *et al.* 2015). Menzel *et al.* (2003) reported larvae on the stems and roots of young *Saintpaulia*, *Antirrhinum* spp., beans, *Schlumbergera*, carnations, chrysanthemums, pelargonia, cucumbers, cyclamen, freesias, geraniums, hydrangea, lettuce, lilies, lucerne, lupins, maize, melon, peas, poinsettia, potatoes, strawberries and sugarbeet. They also noted the species on moorland, waste ground, in deciduous and coniferous forests, and in gardens.

Host plants. We found *B. impatiens* in association with the following (listed alphabetically): *Acacia*, African violets, *Agapanthus*, *Anthurium*, avocado, Azalea, banana, *Banksia*, barley, basil, *Begonia*, bromeliads, *Bougainvillea*, *Buddleia*, cabbage, cacti, *Callistemon*, Chia, *Chrysanthemum*, citrus, *Clivea*, cotton, *Curcuma*, *Cyclamen*, daisy, *Dracaena*, *Eucalyptus*, *Euphorbia*, *Eustoma*, *Eustrephus*, *Ficus*, figs, *Fittonia*, flax, *Fuchsia*, *Gahnia*, *Gardenia*, *Gerbera*, *Grevillea*, *Hardenbergia*, *Harpullia*, *Hebe*, *Hemerocallis*, hoop pine, *Hoya*, *Hydrangea*, *Hymenocallis*, *Impatiens*, *Iris*, *Ixora*, jackfruit, lavender, *Leucanthemum*, *Liriope*, *Lomandra*, *Lophostemon*, Lucerne seedlings, Maidenhair fern, *Mandevilla*, *Mentha, Orthrosanthus*, parsley, passionfruit, *Pelargonium*, Peony roses, *Phalaenopsis*, *Plumeria*, potato, sage, *Sansevieria*, *Schoenoplectus*, *Selaginella*, *Stachys,* stonefruit, strawberry, succulents, sunflowers, *Sutera*, *Tillandsia*, tomato, various herbs and vegetables, *Westringia*.

Distribution. Worldwide in nurseries and greenhouses and often in open landscapes too. The species is documented in the Holarctic from Japan in the East to California in the West. It is less reported from the Southern hemisphere, since the sciarid fauna is poorly studied there in general. In Hawaii and Australia it is known from greenhouses, gardens and open landscapes.

Additional notes. The earliest Australian record in the material that we have examined is from 1963, when *B. impatiens* was collected from “pots, plants and gardens” in Canberra. However it is likely to have been present in Australia for many years prior to this. *Bradysia impatiens* is the most frequently encountered sciarid in Australian greenhouses and it is also widespread, being found in all states and territories, as well as on Norfolk Island (Anon 2015). Of the 775 sciarid adults collected from greenhouses during this study, 485 (62.6%) were *B. impatiens* (85.4% ♂, 14.6% ♀) (Table 1).

TABLE 1. *Bradysia* species that were collected from greenhouses during this study (numbers of individuals, with percentages shown in brackets).

	Male	Female	Total
Bradysia impatiens	414 (85.4)	71 (14.6)	485 (62.6)
Bradysia ocellaris	233 (80.3)	57 (19.7)	290 (37.4)
Total	647 (83.5)	128 (16.5)	775 (100)

Bradysia ocellaris (Comstock, 1882)
(Fig. 3 A–E)

Sciara ocellaris Comstock, 1882 [Comstock (1882): 202–204, plate 17, figs 2–4].
Common synonym: *Bradysia tritici* (Coquillett, 1895).

Literature: Coquillett (1895): 399–402; Steffan (1973a): 356; Steffan (1974): 45; Gagné (1983): 705–706, figs 2 and 2 a–b; Menzel & Mohrig (1991): 21–22 (all as *Bradysia tritici*); Johannsen (1912): 119, 138, plate 7, figs 263 and 265; Lengersdorf (1928–1930): 56, plate 4, fig. 83 (as *Lycoriella* (*Neosciara*) *tritici*); Tuomikoski (1960): 133–134; Menzel & Mohrig (2000): 155–156; Menzel *et al.* (2003): 448, 452, figs 11–22; Mohrig *et al*. (2013): 162–163; Shin *et al*. (2015): 1–8.

Material studied. **QUEENSLAND**: 2 males, hand collection, 4 xii.2013, in PEQ glasshouse with bromeliads, Canvey Road, Ferry Grove, #3A, leg. M. Watts; 3 males, hand collection, 22.x.2014, in greenhouse with tomato and banana plants, Ecosciences Precinct, Dutton Park, #24A, leg. D. Beasley; 1 male, hand collection, 12.xi.2014, in greenhouse with Azaleas, *Ixora* and *Mandevilla* plants, Orchard Road, Redland Bay, #39B, leg. A. Manners; 3 males, hand collection, 11.xi.2014, in greenhouse with *Euphorbia* and African violets, Geldart Road, Chandler, #42A, leg. A. Manners; 4 males, hand collection, 5.ii.2014, in greenhouse with avocado, citrus, hoop pine and passionfruit plants, Ecosciences Precinct, Dutton Park, #43A/43B, leg. A. Manners; 4 males, hand collected, 12.xi.2014, in greenhouse with *Calathea* and *Maranta* plants, Serpentine Creek Road, Redland Bay, #44, leg. A. Manners; 3 males, hand collection, 11.xi.2014, in greenhouse with *Gahnia*, *Banksia*, *Eucalyptus*, *Lomandra* and *Acacia* plants, Sunnydene Road, Capalaba, #45A, leg. A. Manners; 3 males, hand collection, 16.i.2014, in greenhouse with *Cyclamen* plants, Wilkes Court, Tinbeerway, #53, leg. A. Manners; 3 males, hand collection, 12.xi.2014, in greenhouse with *Anthurium*, *Hoya* and *Bougainvillea* plants, German Church Road, Redland Bay, #54A, leg. A. Manners; 2 males, hand collection, 17.xii.2013, in PEQ greenhouse with *Tradescantia*, *Ficus*, *Tabernaemonona*, *Ixora*, *Aglaonema*, *Codiaeum* and *Costus* plants, Mossman, #77 (Bottle 162985), leg. C. Smith (all in PABM).

NEW SOUTH WALES: 1 male, hand collection, 5.xi.2013, in PEQ greenhouse with *Yucca gigantea* and *Sansevieria trifasciata* plants, Moores Road, Glenorie, #15, leg. D. Thackeray (PABM); 2 males, mercury vapour light trap, xi.1978, Wollongbar, ASCT00053527 & 53528, leg. N. Cartwright; 1 male, 25.xi.1994, Rydalmere, ex BCRI Entomology building, ASCT00049087, leg. R. George; 1 male, 9.ix.1994, ex E125, BCRI, Rydalmere, ASCT00054349, leg. D.K. Knihinicki; 1 male, 23.vii.1971, Rydalmere, ASCT0053515, leg. P.J. Walters; 1 male, mercury vapour light trap, 20.i.1979, Barrington Tops National Park, ASCT00053537, leg. G.R. Brown; 2 males, 26.vi.1980, Spring Grove near Lismore, ASCT00053716/ 53717, leg. J. Rand; 1 male, 23.vii.1971, Rydalmere, ASCT00053736, leg. P. Walters (all in ASCU).

AUSTRALIAN CAPITAL TERRITORY: 2 males, vi.1981, Canberra, infesting CSIRO dung beetle cultures, ASCT00053534/53535, unknown collector; 2 males, 12.iii.1966, Canberra, ex cockroach colonies at ANIC, ASCT00053530/53531, leg. M.J. Mackerras (all in ASCU); 2 males, hand collection, 4.ix.2014, in PEQ glasshouse with cotton plants, CSIRO, Black Mountain, #19B (707B-A1288), leg. L. Apps (PABM).

VICTORIA: 1 male, 18.vii.2014, biosecurity intercept, Melbourne (Bottle 224720), *Ficus* plants ex China, leg. R. Protacio; 3 males, hand collection and yellow pans, 23.x.2013, in PEQ glasshouses with strawberry, stonefruit and potato plants, Knoxfield, #17A, leg A. Broadley and L. Sullivan; 3 males, hand collection, 8.xi.2013, in PEQ glasshouse with *Yucca* plants, Heatherton, #18, leg. R. Skipper; 4 males, hand collection, 8.xi.2013, in PEQ glasshouse with *Lilium* and tulips, Monbulk, #21, leg. R. Skipper; 2 males, yellow pans, 18.xi.2014, in seed houses with various ornamentals at Royal Melbourne Botanic Gardens, #37B, leg. D. Robbins; 2 males, hand collection, 19.vi.2014, in glasshouses with *Sansevieria*, sage, various herbs and vegetables, Old Dandenong Road, Heatherton, #48A, leg. A. Manners; 3 males, hand collection, 20.vi.2014, in glasshouse with *Eucalyptus*, *Acacia*, *Correa reflexa*, *Dianella longifolia* and *Billardiera scandens* plants, Jolimont Road, Forest Hill, #49, leg. A. Manners; 2 males, 9.v.2014, biosecurity intercept, Melbourne (Bottle 227591), *Phalaenopsis* orchids ex Taiwan, leg. A. Kosmer; 1 male, yellow pan, 18.i.2015, in vegetable garden, Twin River Drive, South Morang, #74A, leg. A. Broadley; 1 male, hand collection, 5.i.2015, in PEQ glasshouse with *Clivia* plants, Cardigan Road, Mooroolbark (Bottle 246857), #75, leg. R. Skipper (all in PABM).

SOUTH AUSTRALIA: 2 males, hand collection, 22.xi.2013, in PEQ glasshouse with barley plants at Waite Institute (SARDI), #13, leg. N. Luke (PABM).

WESTERN AUSTRALIA: 3 males, hand collection, 25.xi.2013, in PEQ glasshouse 46 with rice, wheat and palm plants, Department of Agriculture and Food, Baron Hay Court, South Perth, #11, leg. J. Cruttenden & S. Boud; 2 males, hand collection, 25.xi.2013, in PEQ glasshouse 45 with barley and wheat plants, Department of Agriculture and Food, Baron Hay Court, South Perth, #12, leg. J. Cruttenden & S. Boud; 3 males, yellow pans, 17.iii.2014, in PEQ glasshouse with *Phalaenopsis* orchids, Oldbury, #1, leg. J. Cruttenden & S. Boud; 2 males, hand collection, 20.xii.2013, in PEQ glasshouse with *Ficus macrophylla*, *Sansevieria laurentii*, *Bambusa textilis*, *Dracaena marginata* and *Ophiopogon jaburan* plants, Safari Place, Carabooda, #7, leg. S. Boud; 4 males, hand collection, 9.xii.2013, in PEQ glasshouse with *Phalaenopsis* orchids, Oldbury, #10B, leg. J. Cruttenden & S. Boud; 4 males, hand collection, 1.v.2014, in glasshouse with *Orthrosanthus laxus* plants, Bingham Road, Bullsbrook, #40A, leg. A. Manners; 4 males, hand collection, 1.v.2014, in glasshouse with *Grevillea* and *Gardenia* plants, Bahen Road, Hacketts Gully, #41B, leg. A. Manners (all in PABM).

NORTHERN TERRITORY: 1 male, yellow pan trap, 3.ii.2015, propagation shade house with *Cucuma*, jackfruit and fig plants, Makagon Road, Darwin, #85A, leg. M. Finlay-Doney (PABM).

TASMANIA: 3 males, hand collection, 31.x.2013, glasshouse with sunflowers in peat mix, New Town Research Labs, #14B, leg. G. Anderson; 3 males, hand collection, 20.xi.2014, in Glasshouse 3 with *Begonia* plants, Royal Tasmanian Botanical gardens, Queens Domain, Hobart, #78A, leg. N. Tapson (all in PABM).

Bradysia ocellaris was described from galls contaminated with larvae in a laboratory in Ithaca, New York, USA (Comstock 1882). It is distributed worldwide and very common in greenhouses but also in pot plants in houses. Moreover, it is known as a pest in commercial mushroom cultures. Larvae were found feeding on decaying sugar cane, pineapple, wheat seedlings and many cultivated crops. Females are monogenic or more often digenic in laboratory rearing (Steffan 1974). The species is phytosaprophagous, mycetophagous and phytophagous. In warmer countries it is common in open landscapes. In temperate climates like in Europe it is a thermophile and lives in southern exposed biotopes and in southern countries.

Diagnostic remarks. The species is well characterized by a yellowish body colour with darker spots on the pleural sclerites (in both sexes), yellowish scape, pedicel and first 2–3 flagellomeres (the basal segments of the antenna are seldomly more or less dark). Flagellomeres have a rough surface and bicoloured necks. The palpi have a deep sensory pit on the basal segment. The gonostylus has an apical tooth and 3(–4) subapical spines, 2 within equally long dense hairs on the apex. The third stands isolated at the end of the distal third of the gonostylus. The tegmen is trapezoidal in shape and has a large area of teeth.

Menzel *et al.* (2003) examined male specimens collected from Kuranda, near Cairns (Queensland) and reported that *B. ocellaris* males in the Australian region differ from males in other zoogeographic regions by having longer and narrower flagellomeres (4th flagellomere 3.5–4.0 times width). All of the specimens that we examined had flagellomeres of the normal length (4th flagellomere = 2.2–2.5 times width).

The nomenclature of the species is discussed in Menzel & Mohrig (2000): pp. 155–156 and Mohrig *et al.* (2013): pp. 167–168. Shin *et al.* (2015) used mitochondrial cytochrome c oxidase (COI) DNA barcoding and detected interspecific genetic divergence of the COI region within the genus *Bradysia*. They identified these morphologically as *B. ocellaris*-like within the *B. tilicola* species group and concluded that *B. ocellaris* may comprise a complex of at least three cryptic species. We believe that this needs further investigation and that species closely related to *B. ocellaris* may exist, but they are unlikely to be morphologically identical to this common greenhouse pest species. It is worth noting here too that Mohrig *et al.* (2013) erroneously reported that *B. ocellaris* belongs to the *B. tilicola* species group. *Bradysia ocellaris* actually belongs to a group of species, originating from the Eastern Palaearctic or East Asia, which may be related to the *B. hilaris* group.

Economic importance. Referred to by orchid growers as the "moss fly" in a number of earlier publications. Menzel *et al.* (2003) reported the species from glasshouses, commercial mushroom houses (*Agaricus blazei*, *A. brunnescens*, *A. bitorquis*, *Auricularia* spp., *Pleurotus cystidiosus* and *P. ostreatus*), other dwellings, in gardens on ornamental plants, in deciduous woods and on stream banks in reeds and moss. Larvae were found feeding on the roots and/or stems of campanula, carnations, corn, cucumbers, geraniums, lettuce, nasturtiums, young orchid plants, peas, pineapple, poinsettia, potato tubers, primula seedlings, sugar cane, wheat, and in the soil around cactus plants. The species is very common in greenhouses, palm houses, winter gardens and in pot plants. It is a major mushroom pest in Australia according to Shamshad (2010).

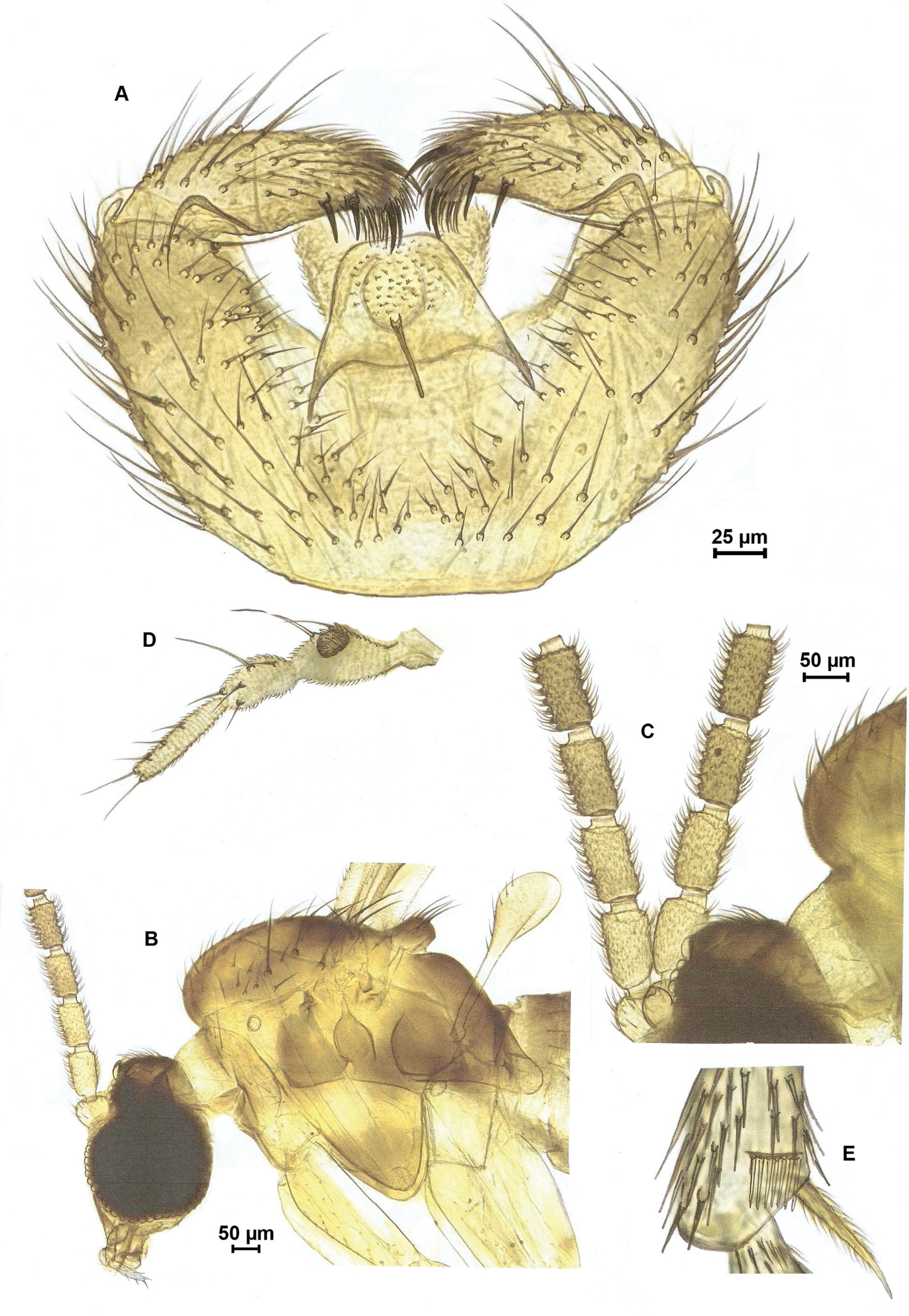

FIGURE 3. *Bradysia ocellaris* (Comstock, 1882). A. Hypopygium. B. Head and thorax. C. Basal segments of antenna. D. Palpus. E. Fore tibia.

Host plants. We found *B. ocellaris* in association with the following (listed alphabetically): *Acacia*, African violets, *Aglaonema*, *Anthurium*, avocado, Azaleas, *Bambusa*, banana, *Banksia*, barley, *Begonia*, *Billardiera*, bromeliads, *Bougainvillea*, *Calathea*, citrus, *Clivia*, *Codiaeum*, *Correa*, *Costus*, cotton, *Cucuma*, *Cyclamen*, *Dianella, Dracaena*, *Eucalyptus*, *Euphorbia*, *Ficus*, fig, *Gahnia*, *Gardenia*, *Grevillea*, herbs, hoop pine, *Hoya*, *Ixora*, jackfruit, *Lilium*, *Lomandra*, *Mandevilla*, *Maranta*, *Ophiopogon*, *Orthrosanthros*, palms, passionfruit, *Phalaenopsis*, potato, rice, sage, *Sansevieria,* stonefruit, strawberry, sunflowers, *Tabernaemonona*, tomato, *Tradescantia*, tulips, wheat, *Yucca*.

Distribution. Cosmopolitan, common in both hemispheres (Menzel & Mohrig 1991; Menzel & Smith 2009).

Additional notes. 290 of the 775 sciarid adults collected from greenhouses during this study were *B. ocellaris* (37.4%; 80.3% ♂ and 19.7% ♀), the most frequently encountered sciarid in greenhouses after *B. impatiens* (Table 1). The earliest record in the material that we have examined is from 1966, when specimens were collected from live cockroach colonies held at the Australian National Insect Collection (ANIC) in Canberra. In Australia *B. ocellaris* is present in all mainland states and territories as well as Tasmania.

Cosmosciara hartii **(Johannsen, 1912) comb. n.**

(Figs 7 A–B, 8 A–C, 9 A–D)

Sciara hartii Johannsen, 1912 [Johannsen (1912): 144].
Common synonyms: *Plastosciara perniciosa* Edwards, 1922; *Epidapus semifactus* Mohrig & Röschmann, 1999.
= ***Plastosciara perniciosa*** **Edwards, 1922 syn. n.** [Edwards (1922): 160–161].

Literature: Pettey (1918): 325, fig. 67 (as *Neosciara hartii*); Steffan (1966): 36, 53 (as *Bradysia hartii*); Mohrig *et al*. (2013): 223–224, fig. 43 a–c (as *Pnyxia hartii*); Frey (1942): 24, 39 (as *Cosmosciara perniciosa*); Frey (1948): 71, 88, pl. 22, fig. 130 (as *Plastosciara* (*Cosmosciara*) *perniciosa*); Lengersdorf (1928–30): 13–14, pl. 1, fig. 10; Steffan (1973b): 1265–1266, figs 1–2; Steffan (1974): 48 (all as *Plastosciara perniciosa*); Tuomikoski (1960): 39; Freeman (1983): 25, 51, figs 49, 52, 60 (both as *Plastosciara* (*Termitosciara*) *perniciosa*); Rulik *et al.* (1999): 31–32, fig. 7 a–e (as *Epidapus semifactus*); Menzel & Mohrig (2000): 288–289 (as *Cratyna* (*Peyerimhoffia*) *perniciosa*); Mohrig (2003): 64–65, fig. 46 a–d (as *Epidapus* (*Clandestina*) *perniciosus*); Menzel & Heller (2007): 216–218 (as *Cosmosciara perniciosa*).

Material studied. **WESTERN AUSTRALIA:** 1 male (morphotype I), 27.ii.2015, (Barcode of Life GMCWT350-15; dx.doi.org/10.5883/DS-SCIARWA; GenBank accession MG647953), Cockburn Wetlands Education Centre, -32.0865S 115.831E, malaise trap, leg. D. Crosbie (BIOUG).

Other material: 2 males, 14.iii.2014, biosecurity intercept, (#5), in compost, wood mulch and leaf litter used to rear Lucanidae beetles ex China, hand collection, leg. C. Rajapakse (PABM, PWMP); 2 males (maggot-like morphotype II), 4.viii.2006, biosecurity intercept (Bottle #95085), taro ex Fiji, leg. C. Eather. Specimens were photographed and destroyed by PCR analysis.

Remarks. We now consider that *Sciara hartii* Johannsen is *Cosmosciara perniciosa* (Edwards), based upon a repeated study of the partly destroyed hypopygium of the type species. The gonostylus has a fine hyaline spine below the apical tooth, the palpus is 1-segmented and the flagellomeres are short. Both species have also been bred from cucumbers (Johannsen 1912; Edwards 1922). Therefore, *Cosmosciara perniciosa* (Edwards 1922) is regarded as a junior synonym of *Cosmosciara hartii* (Johannsen, 1912).

The species is widespread and reported from numerous countries in both the northern and southern hemispheres. It is often associated with plant nurseries and is sometimes a pest. Like all greenhouse sciarids it has a population in open landscapes. In this case the larvae are phytosaprophagous and will also feed on rotting wood.

Cosmosciara hartii is a highly exceptional species because of an extreme morphological polymorphism in both sexes. Morphotype I includes fully winged males and females, which do not differ morphologically in body structures from other winged sciarids (figs 7, 8, 9 B). Morphotype II bears extraordinary modifications of all body structures (figs 9 A, C, D). The wings are micropterous, with strongly reduced legs and halteres as well as reduced eyes, ocelli and antennae, and the thorax has reduced sclerite borders. The genitalia do not show a strong reduction in both morphotypes (they are a little bit smaller and the apical tooth on the gonostylus is somewhat shorter than in winged males). The micropterous morphotype II develops under optimal conditions of larval feeding, whereas the winged morphotype I is common in larval habitats with limited resources where migration is necessary (Steffan 1973b).

Diagnostic remarks. Winged male specimens are characterised by a reduced palp with a large basal segment lacking a sensory pit, and a very small rudimentary second segment. The flagellomeres are short (l/w index 1.2) with long and strong bristles (longer than the diameter of the basal node) and rather long necks. The fore tibia is without a distinct patch of bristles and with one short spur. The mid and hind tibiae have two short spurs. The gonostylus is pointed towards the apex, with a short subapical tooth, possessing a few fine microtrichia at the tip and 1–2 fine stiff bristles. The tegmen is wider than long and trapezoid in shape. The micropterous specimens are maggot-like, with short rudimentary wings, halteres and legs, strongly reduced eyes and shortened antennae.

Economic importance. Sometimes found breeding en masse in plant nurseries, but not usually as common as other pest species. Reported as a pest of cucumbers grown under glass near Saint Petersburg (Leningrad), Russia (Gerbatchevskaya 1963), in the UK (Edwards 1922; Hussey *et al.* 1969) and USA (Johannsen 1912; Mohrig *et al.* 2013). Common in open landscapes (herb gardens, moors, alder forest and deciduous woodland (Menzel & Smith 2009). Freeman (1983) noted that it has been collected from the nest of the ant *Myrmica ruginodis* Nylander. One male specimen (morphotype I) was collected in a malaise trap in Western Australia: this is the first Australian record. It has also been intercepted during the on-arrival biosecurity inspection of a consignment of taro imported from Fiji, and found in association with beetle rearing substrate intercepted from China.

Distribution. Probably cosmopolitan, known so far from the Holarctic (from China to Europe and the USA); Afrotropical region (United Arab Emirates, Tristan da Cunha Islands, Seychelles); Neotropical region (Costa Rica, Galápagos Islands), Australasia (Australia); Polynesia (French Polynesia, Hawaiian Islands); Oriental region (Philippines).

Genus *Lycoriella* Frey, 1948

The genus *Lycoriella* consists of three subgenera *Lycoriella* Frey, 1948 s. str., *Hemineurina* Tuomikoski, 1960 and *Coelostylina* Tuomikoski, 1960. Pest species are known from the subgenus *Lycoriella* s. str. only. Species of this subgenus are rather easy to differentiate from species of other genera as well as from the other two subgenera because of the following characteristics: tibial organ with a horseshoe-shaped border apically on the fore tibia, a 3-segmented palpus with a deep and dark sensory pit on the basal segment, scutum with short hairs, bare posterior wing veins, an intergonocoxal lobe or a bristle group on the ventral base of the hypopygium, a slender gonostylus with an apical tooth, a number of spines on the inner side and a long whiplash hair (sometimes two) behind the basal-most spine.

There are about 24 species in the subgenus from the Palaearctic region distributed exclusively across the Holarctic, except the pest species which have spread worldwide. The species prefer temperate zones in Eurasia and North America, but not northern or mountainous areas as preferred by species of the subgenera *Hemineurina* and *Coelostylina*.

The pest species have been transported by humans to subantarctic islands (Crozet Islands, Kerguelen Islands, Tristan da Cunha archipelago, South Georgia) and to at least one Antarctic research base where they appear to have established stable populations.

Lycoriella agraria (Felt, 1898)

(Fig. 4 A–E)

Sciara agraria Felt, 1898 [Felt (1898): 223, figs 1, 2, 11].
Common synonyms: *Lycoriella multiseta* (Felt, 1898); *Lycoriella cellaris* (Lengersdorf, 1934).

Literature: Johannsen (1912): 120, 130, fig. 124 (as *Sciara multiseta*); Lengersdorf (1934): 24, fig. 1 (as *Neosciara cellaris*); Tuomikoski (1960): 79, 85, figs 17c, 18f, 19c, 20f; Menzel & Mohrig (2000): 392 (both as *Lycoriella cellaris*); Mohrig *et al.* (2013): 209–210, fig. 35 a–c.

Material studied. **NEW SOUTH WALES**: 4 males, 24.viii.1978, Rydalmere, ASCT00049044/49046/49047 (ASCU)/ASCT00049045 (PWMP), leg. B.J. Loudon; 1 male, 25.viii.1978, Rydalmere, ex lab culture, ASCT00049049 (ASCU), leg. B.J. Loudon; 1 male, 8.viii.1978, Rydalmere, ex lab culture, ASCT00049050

(ASCU), leg. B.J. Loudon; 8 males, 14.vii.1978, Rydalmere, ex lab culture, ASCT00050455 (PWMP)/ ASCT00050456-50457 (ASCU)/ASCT00054780 (PWMP) - 54784/54798, leg. B.J. Loudon (ASCU); 6 males, 11.vii.1978, Rydalmere, ex lab culture, ASCT00050442/50446 (ASCU)/50454 (PWMP)/54789/54791/54793 (ASCU), leg. B.J. Loudon; 2 males, 19.viii.1981, Rydalmere, poultry manure heap, ASCT00050458/50459, leg. B.J. Loudon (ASCU); 1 male, 5.ix.1980, Rydalmere, around mushroom house, ASCT00054752, leg. A.D. Clift (ASCU); 1 male, ii.1981, Wollongong, in mushroom house, ASCT00054776, unknown collector (ASCU); 1 male, 8.ix.1980, East Parramatta, in house, ASCT00054773, leg. S.R. Brown (ASCU); 1 male, 11.v.1978, George's Hall, Sydney, ex mushroom compact, ASCT00054764, leg. A.D. Clift (ASCU); 1 male, 6.xi.1979, Maralya, ex mushroom compost, ASCT00054754, leg. A.D. Clift (ASCU); 1 male, 26.iv.1977, Bowral, ASCT00049051, leg. B.J. Loudon (ASCU); 15 males, 6.x.1978, Rydalmere, ASCT00049012-49026, leg. B.J. Loudon (ASCU); 9 males, 20.vii.1978, Rydalmere, ex lab culture, ASCT00049027-49031/50440/50441/50443/50447, leg. B.J. Loudon (ASCU); 4 males, 13.vii.1979, Rydalmere, ex lab culture, ASCT00049032-49034/50444, leg. B.J. Loudon (ASCU); 6 males, 8.ii.1978, Rydalmere, ex lab culture, ASCT00049037/49038/50438/50445/50448/50449, leg. B.J. Loudon (ASCU); 3 males, iv.1978, Rydalmere, ex lab culture, ASCT00050450-50451/54740, leg. B.J. Loudon (ASCU); 2 males, 24.viii.1978, Rydalmere, ex lab culture, ASCT00054787 (PWMP)/54788 (ASCU), leg. B.J. Loudon; 2 males, 22.vi.1978, Rydalmere, ex lab culture, ASCT00077096-77097, unknown collector (ASCU).

VICTORIA: 8 males, iv.1978, Rydalmere, ex lab culture origin Melbourne, ASCT00049041/49041/50377/ 50460/50507/50508/54741/54742, leg. B.J. Loudon (ASCU); 1 male, mercury vapour lamp, 31.v.1977, Melbourne, ASCT00050453 (ASCU), leg. B.J. Loudon; 1 male, yellow pan trap in vegetable garden, xi.2015, Twin River Drive, South Morang, Victoria, # 86, leg. A. Broadley (PWMP); 6 males, MV light, 31.v.1977, Melbourne, ASCT00050509/54806/54809/54810/54812/54814, leg. A.J. Stocker (ASCU); 1 male, 11.xi.1975, ex mushroom farm, Pearcedale, ASCT00054816, unknown collector (ASCU); 3 males, iii.1977, Melbourne, ASCT00054800-54802, leg. A.J. Stocker (ASCU); 1 male, March 1977, ex lab culture, ASCT00054803, leg. A. J. Stocker (PWMP); 1 male, 22.viii.1977, Melbourne, ex lab culture, ASCT00000050439 leg. A.J. Stocker (ASCU).

Lycoriella agraria (Felt) was first collected from mushrooms in Albany, USA; as *L. cellaris* (Lengersdorf, 1934) in a house cellar, Bohemia, Czech Republic; from rotting straw in Finland [*L. stramentorum* (Frey, 1948)] and from a cave in Afghanistan (*L. rufula* Tuomikoski, 1960). It was reared from birds' nests, rabbit burrows and squirrel drey in the United Kingdom (Freeman 1983). The species is rather seldomly found in Europe and seems to be more common in North America (Mohrig *et al*. 2013) and in Australia according to the data presented here.

Diagnostic remarks. *Lycoriella agraria* (Felt) is easy to identify as belonging to *Lycoriella* s. str. because of the following characteristics: a horseshoe-shaped border of the tibial organ on the fore tibia, a 3-segmented palpus with a deep and dark sensory pit on the basal segment, a densely haired intergonocoxal lobe on the ventral base of the hypopygium, a slender gonostylus with an apical tooth and a different number of spines as well as a long whiplash hair on the inner side. It differs from the two other pest species by having 3 spines inserted separately on the inner side of the gonostylus and a densely haired broad intergonocoxal lobe.

Economic importance. The first Australian record of *Lycoriella agraria* in the BCRI material is from 1975. This species has been collected from mushroom beds, mushroom compost and poultry manure in Victoria and New South Wales. It was reported as a damaging pest of mushrooms in a cellar in New York, USA by Felt (1898).

Distribution. Holarctic: Europe, Afghanistan, North America (USA, Canada); Australia.

Lycoriella ingenua (Dufour, 1839)

(Fig. 5 A–E)

Sciara ingenua Dufour, 1839 [Dufour (1839): 29–31, plate I, figs 20–28].
Common synonyms: *Lycoriella caesar* (Johannsen, 1929); *Lycoriella mali* (Fitch, 1856); *Lycoriella solani* (Winnertz, 1871).

= ***Sciara womersleyi* Séguy, 1940 syn. n.** [Séguy (1940): 210, fig 6].
We studied 2 females collected from the Kerguelen Islands on 21.xi.1929, deposited in the South Australian Museum, Adelaide (3 slides #29-003430-29003432, marked as syntypes). When compared with European specimens and taking into account the corresponding body size, it is a junior synonym of *L. ingenua*.

Literature: Fitch (1856): 484 (as *Molobrus mali*); Winnertz (1871): 855 (as *Sciara solani*); Tuomikoski (1960): 79, 84, figs 18 e, 20 e (as *Lycoriella solani*); Steffan (1972): 429–431, figs. 1 a–h (both as *Lycoriella solani*); Steffan (1973a): 357–358;

Steffan (1974): 47 (both as *Lycoriella mali*); Menzel & Mohrig (2000): 393–396; Menzel & Müller (2009): 43–48, figs 1–5; Mohrig *et al*. (2013): 211–212.

Material studied. **NEW SOUTH WALES**: 5 males, 11.v.1978, George's Hall, Sydney, ex mushroom compact, ASCT00054761 (PWMP) / 54762/54763 (ASCU) / 54765 (PWMP)/54770 (ASCU), leg. A. D. Clift; 1 male, 13.vii.1979, Rydalmere, ex lab culture, ASCT00049035, leg. B.J. Loudon (ASCU); 3 males, 6.xi.1979, Maralya, ex mushroom compost, ASCT00054753/54755/54756, leg. A.D. Clift (ASCU).

TASMANIA: 1 male, 5.v.1984, Devonport, hyacinth bulbs, 7207, 82844, leg. unknown (TAIC).

AUSTRALIAN ANTARCTIC TERRITORY: 5 males, 2004, Casey Station, Waste Water Treatment Depot, leg. S. Richards (PABM).

The species was reared and described from larvae feeding on champignons (*Boletus imbricans*). It is common in mushroom farms, greenhouses, rotting potatoes and a range of other crops and is common in open landscapes. It is phytosaprophagous and mycetophagous, and also feeds on plasmodia of slime moulds. Females are digenic (Steffan 1973a). The species is reported as common and with stable populations on subantarctic islands and has been reported from Casey Station in the Australian Antarctic Territory after being transported there via human activity (Séguy 1940; Steffan 1974; Hughes *et al.* 2005).

Diagnostic remarks. The species can easily be identified as belonging to *Lycoriella* s. str. because of the following characteristics: a horseshoe-shaped border surrounds the tibial organ on the fore tibia, a 3-segmented palpus with a deep and dark sensory pit on the basal segment, a hairy intergonocoxal lobe on the ventral base of the hypopygium, a slender gonostylus with an apical tooth and a different number of spines as well as a long whiplash hair on the inner side. It differs from the other two pest species by having a long gonostylus, evenly pointed toward the apex, and 6–7 short hyaline spines on the inner side.

Economic importance. Recorded from decaying potatoes in the USA (Felt 1898). "Normally feeds on rotting plant tissues and is frequently found in damaged bulbs, slug-eaten celery roots, potato tubers, and on tomato roots affected by brown root rot" although it also damages the roots of azalea and *Mesembryanthemum* sp. (Hussey *et al.* 1969). Freeman (1983) stated that "it is common around houses, breeding in decaying potatoes, bulbs, household refuse etc. and can be a damaging pest in mushroom houses." This species has also been reported damaging mushrooms and cucumbers under glass and table beets in storage in Leningrad province, Russia (Gerbatchevskaya 1963).

Distribution. Holarctic; Hawaii, Subantarctic Islands, Australia, Australian Antarctic Territory (new record).

Additional notes. The first record of this species in the BCRI material is from 1978, so *L. ingenua,* like *L. agraria*, appears to be a relatively recent arrival in Australia. We have so far examined material collected from New South Wales and Tasmania. We also examined specimens collected from the waste water treatment depot at Casey Station in the Australian Antarctic Territory. The fly has been present there since 1998 (Hughes *et al.* 2005). According to Clift & Larsson (1984) and Greenslade & Clift (2004), *L. ingenua* replaced *L. sativae* as the major mushroom pest in New South Wales in the mid 1980's. However, we found during our examination of the BCRI slide collection that *L. ingenua* was the least common of the three *Lycoriella* species [*L. ingenua*: 50 slides (14.5%); *L. agraria*: 145 slides (42%); *L. sativae*: 150 slides (43.5%)]. Many specimens that had previously been identified as *L. ingenua* in the BCRI material were misidentified and were actually *L. agraria*. Fresh collections of sciarids from mushroom houses should be made to confirm which *Lycoriella* species are the primary pests of cultivated mushrooms in Australia today.

Lycoriella sativae (Johannsen, 1912)
(Fig. 6 A–D)

Sciara sativae Johannsen, 1912 [Johannsen (1912): 133, figs 120, 240].
Common synonyms: *Lycoriella agarici* (Loudon, 1978); *Lycoriella castanescens* (Lengersdorf, 1940); *Lycoriella fucorum* (Frey, 1948).

= ***Sciara auberti*** **Séguy, 1940 syn. n.** [Séguy (1940): 211–212, figs 2–5].
Séguy described a male and a female collected by E. Aubert in March 1931 from Port Jeanne-d´Arc in the Kerguelen Islands. The short gonostylus with 4 spines in the middle of the inner side (fig. 3) is consistent with *L. sativae*. It is a junior synonym of that species. The deposition of the type was not mentioned by the author. Perhaps it is deposited in Paris.

= ***Sciara jeanneli* Séguy, 1940 syn. n.** [Séguy (1940): 210–211, fig. 1].

The species was described on the basis of two females collected on 6.ii.1939 from the South-east region, Golfe du Morbiham, Port Jeanne-dÀrc, in the Kerguelen Islands. We have not studied this species but we believe that the wing venation and body size (1.75 mm, as in *Sciara auberti*) is consistent with *L. sativae* and so *Sciara jeanneli* is a junior synonym too. The deposition of the type was not mentioned by the author.

= *Sciara solispina* Hardy, 1956 syn. n. [Hardy (1956): 84–85, fig. 9a–c].

= ***Lycoriella solispina* (Hardy, 1956) syn. n.** [Steffan (1973a): 358].

This species was described on the basis of a male collected by D.E. Hardy in October 1952 from Kaula Gulch, on the north slopes of Mauna Kea, Hawaii, at 7000 ft. The holotype is deposited in the Bernice Pauahi Bishop Museum (slide 2489). We have examined this specimen and it is identical to *L. sativae*.

Literature: Frey (1948): 60, 80, fig. 68 (as *Lycoriella* (*Chaetosciara*) *fucorum*); Loudon (1978): 163, figs 1–8 (as *Lycoriella agarici*); Tuomikoski (1960): 82, 88, figs 17 g, 18 d, 20 d; Freeman (1983): 31, figs 93, 102; (both as *Lycoriella auripila*); Menzel & Mohrig (2000): 386–389, figs 353–355 (as *Lycoriella castanescens*); Mohrig *et al.* (2013): 216–217, fig. 39 a–d.

Material studied. **QUEENSLAND**: 2 males, 24.x.1977, Southport, in mushroom compost (fungi-peat), ASCT00050416/50417, leg. G. McCartney (ASCU).

NEW SOUTH WALES: 1 male, ix.1936, Sydney, mushroom beds, ASCT00050462, unknown collector; 2 males, 19.vii.1977, Wilberforce, ex mushrooms, ASCT00050432/50435, leg. A.D. Clift (ASCU); 3 males, 5.ix.1980, Rydalmere, around mushroom house, ASCT00050379/50434/54496, leg. A.D. Clift (ASCU); 1 male, v.1980, Lake Tandau, near Menindee, in Lucerne, ASCT00050431, leg. B. Dominiak; 2 males, 30.i.1980, Tolson's Farm, Windsor, mushroom compost, ASCT00050429/77126, leg. A.D. Clift; 1 male, 10.xi.1962, Rydalmere, ex glasshouse bean pots, ASCT00050421, leg. F.A. Gibson; 1 male, MV light, 26.iv.1980, Alstonville, ASCT00050420, leg. N.W. Cartwright; 2 males, vii.1980, Griffith, from miniature mushroom farms, ASCT00050418/77123, unknown collectors; 5 males, 6.xi.1979, Johnston's, Windsor, ex mushroom house, ASCT00050393/50395/50411-50413, unknown collector; 3 males, 30.i.1980, Baker's Farm vineyard, ex mushroom compost, ASCT00050408-50410, leg. A.D. Clift; 1 male, rotating net trap, 2.xii.1978, Jerilderie, ASCT00050407, leg. J. McGechan; 1 male, 6.xii.1978, Jerilderie, ASCT00050406, leg. J. McGechan; 4 males, x.1981, Tamworth, ex mushroom compost, ASCT00050386/50400-50402, leg. N. Forrester; 17 males, 12.xi.1981, Otford, ex mushroom tunnel farm, ASCT00050398/50399/54494/54497-54503/77098-77104, leg. A.D. Clift; 1 male, MV light, 22.x.1979, Rydalmere, ASCT00050380, leg. B.J. Loudon; 1 male, 29.iv.1978, Royal National Park, ASCT00050385, leg. B.J. Loudon; 1 male, light trap, 12.ix.1978, Rydalmere, ASCT00050378, unknown collector; 3 males, 19.iv.1977, Bathurst, ex mushroom farm, ASCT00050394/54495/54835, leg. B.J. Loudon; 2 males, xi.1976, Windsor, ex mushroom farm, ASCT00054469/77124, leg. B.J. Loudon; 2 males, 26.iv.1977, Bowral mushroom nursery, ASCT00050389/54842, leg. B.J. Loudon; 2 males, xi.1981, Sydney, ex mushroom compost, ASCT00050397/77122, leg. A.D. Clift; 1 male, 19.vii.1977, Wilberforce, ex mushrooms, ASCT00050396, leg. A.D. Clift; 1 male, 22.iv.1980, Johnston's, Windsor, ex mushroom farm, ASCT00077125, unknown collector; 19 males, 31.vii.1978, Rydalmere, ASCT00077077-77095, unknown collector (all in ASCU).

AUSTRALIAN CAPITAL TERRITORY: 3 males, 27.xi.1979, Canberra, infesting cultivated mushrooms, ASCT00050381-50383, leg. B.J. Loudon; 1 male, 14.vii.1964, Canberra, ex soil under rotting *Boletus*, ASCT00050384, leg. D.H. Colless (all in ASCU).

VICTORIA: 5 males, xii.1979, Bundoora, Melbourne, ex mushroom compost, ASCT00050392/50403-50405/50419, leg. A.D. Clift (ASCU); 4 males, xi.2015, Twin River Drive, South Morang, Victoria, # 86, yellow pan trap in vegetable garden, leg. A. Broadley (PABM).

SOUTH AUSTRALIA: 2 males, xi.1978, Adelaide, ex mushroom compost, ASCT00050414/50415, leg. A.D. Clift (ASCU).

TASMANIA: 1 male, 26.viii.1980, Lachlan, pasture pitfall trap, 82854, 85G4, 05(D), leg. J.E. Ireson (TAIC).

NORFOLK ISLAND: 3 males, 26.xi.2014, *Culicoides* light trap in trees, Anson Bay, #32, leg. A. Broadley; 3 males, 24.x.2013, yellow pans set near vegetables, #33 (AW-28), leg. A. Wells; 2 males, 23.x.2013, yellow pans pan traps set near vegetables, #34A (AW-17), leg. A. Wells. [Anonymous, 2015] (all in ANIC).

L. sativae was described from an open landscape (meadow). It is a common species in cultivated fields and diverse natural habitats but it is also a common pest in greenhouses and mushroom cultures, where it breeds en masse and is of considerable economic importance.

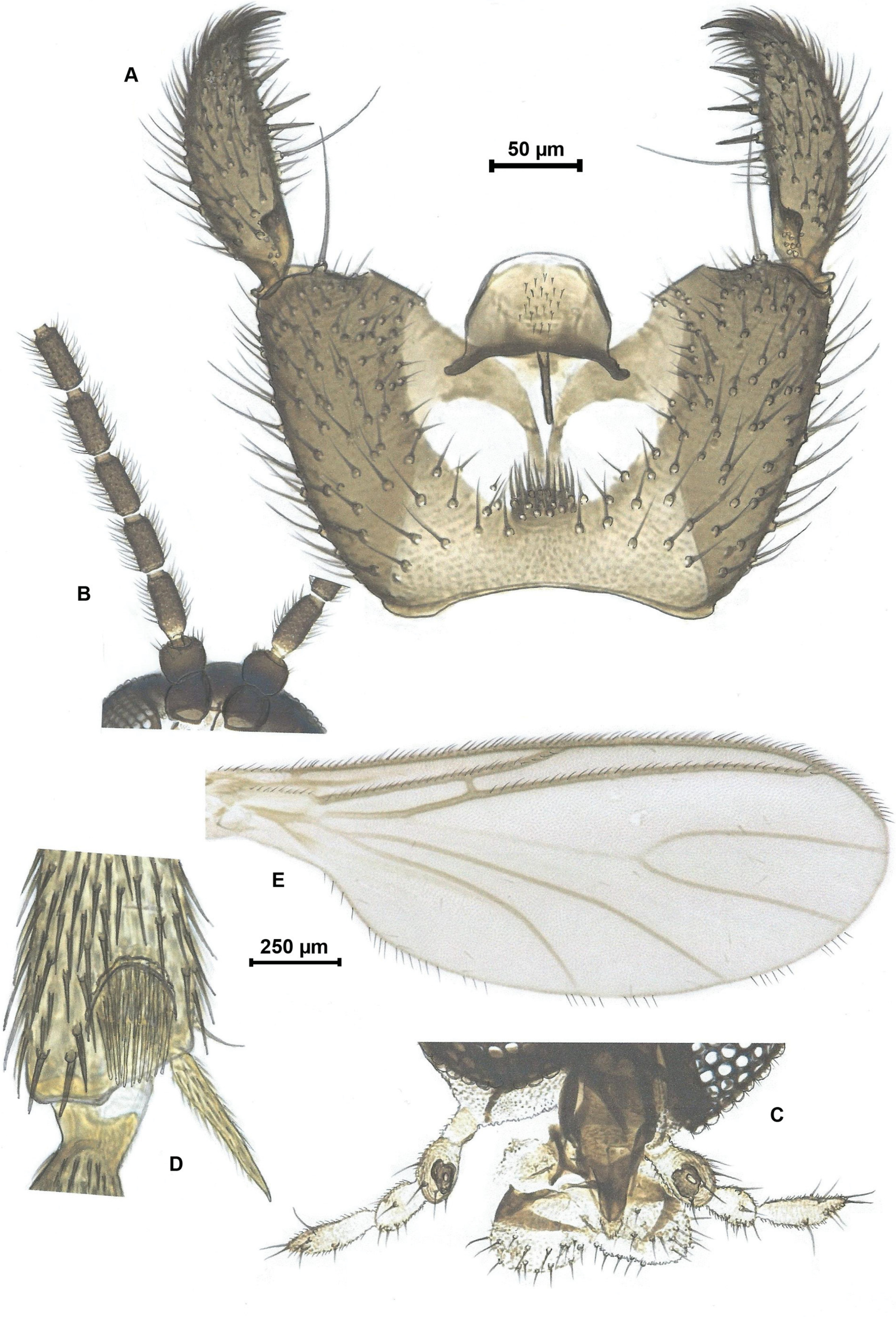

FIGURE 4. *Lycoriella agraria* (Felt, 1898). A. Hypopygium. B. Basal segments of antenna. C. Palpus. D. Fore tibia. E. Wing.

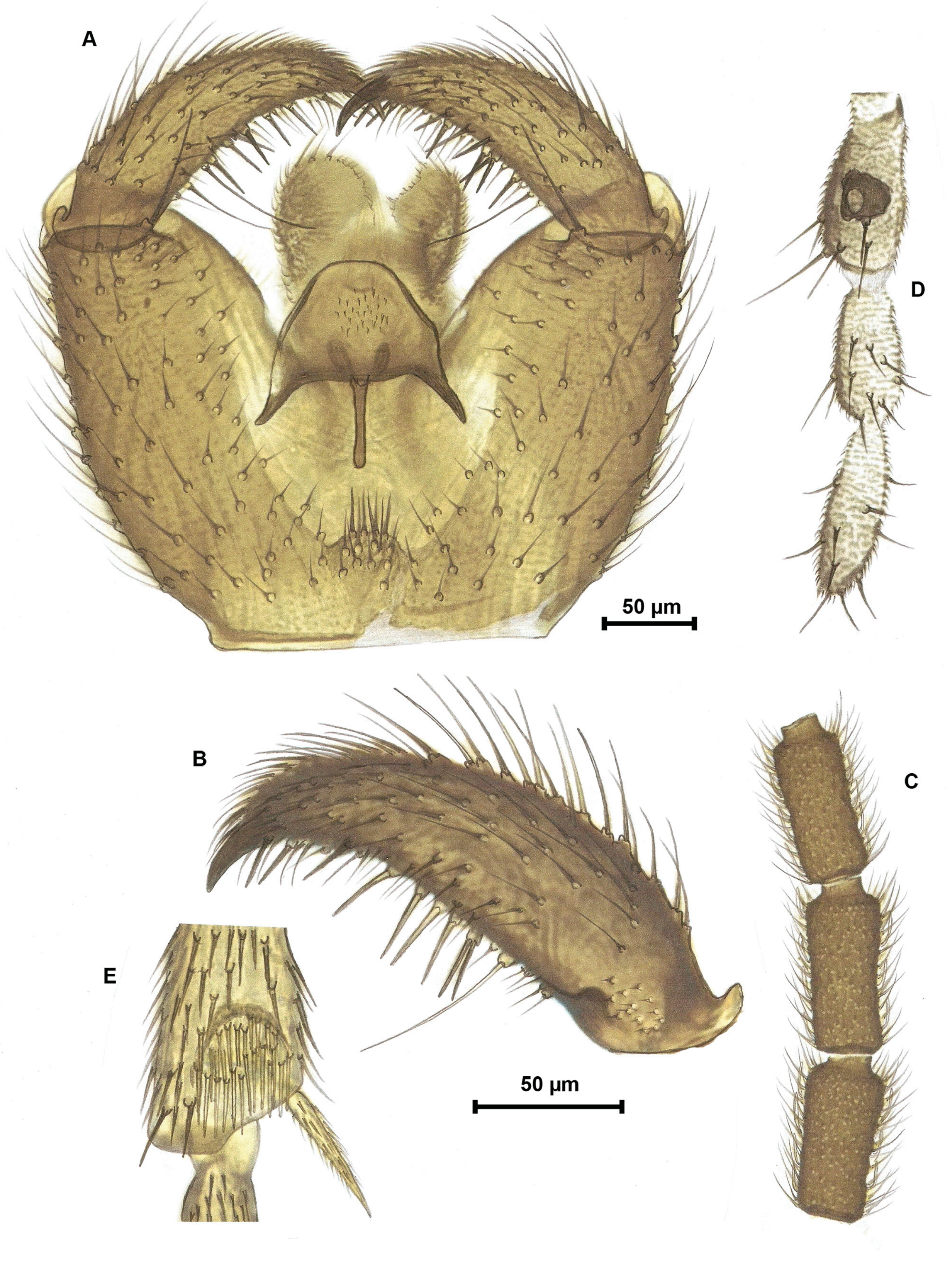

FIGURE 5. *Lycoriella ingenua* (Dufour, 1839). A. Hypopygium. B. Gonostylus. C. Flagellomeres 2–4. D. Palpus. E. Fore tibia.

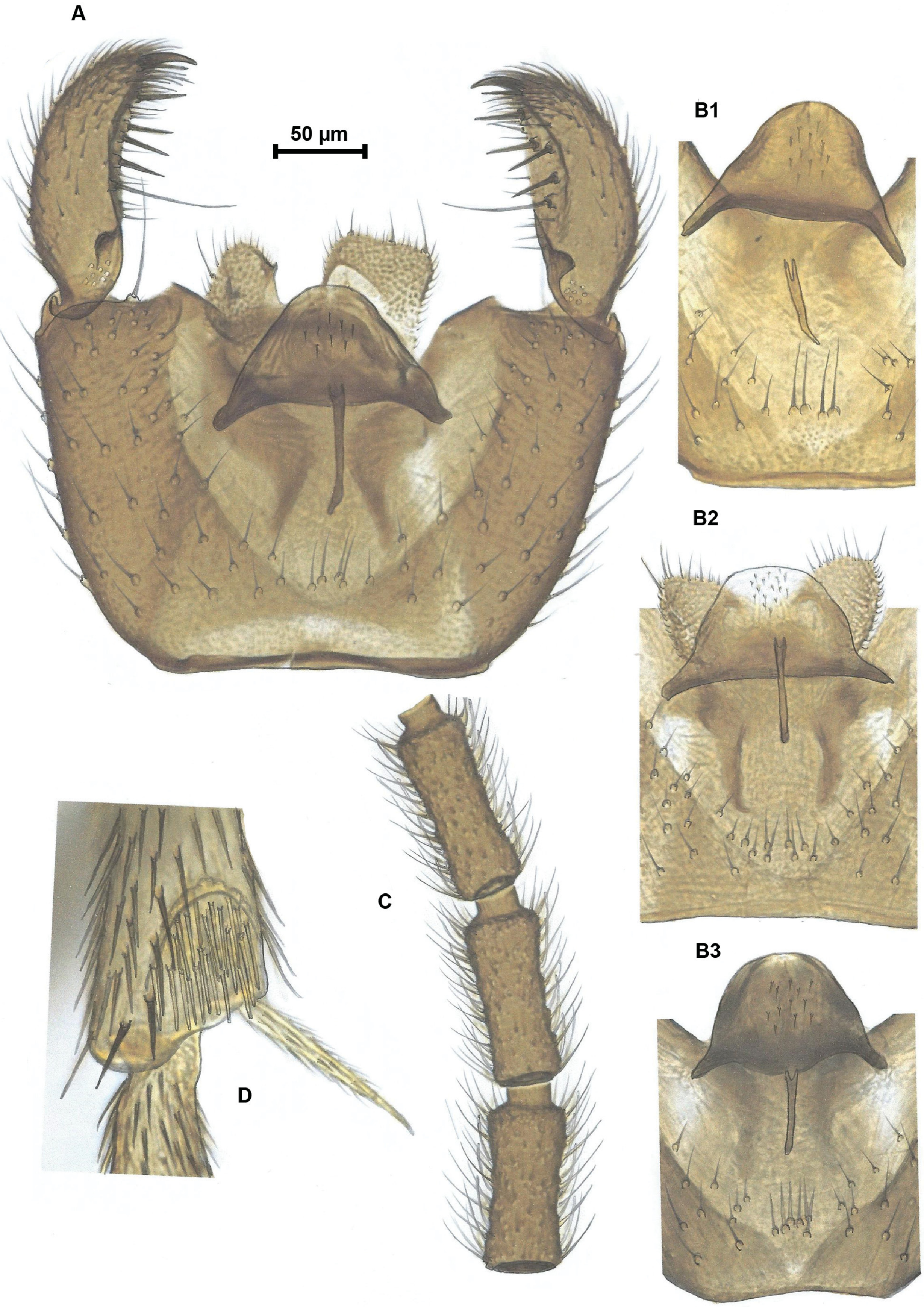

FIGURE 6. *Lycoriella sativae* (Johannsen, 1912). A. Hypopygium. B1-B3. Ventral bases of hypopygium (intergonocoxal membrane with bristle patch). C. Flagellomeres 3–5. D. Fore tibia.

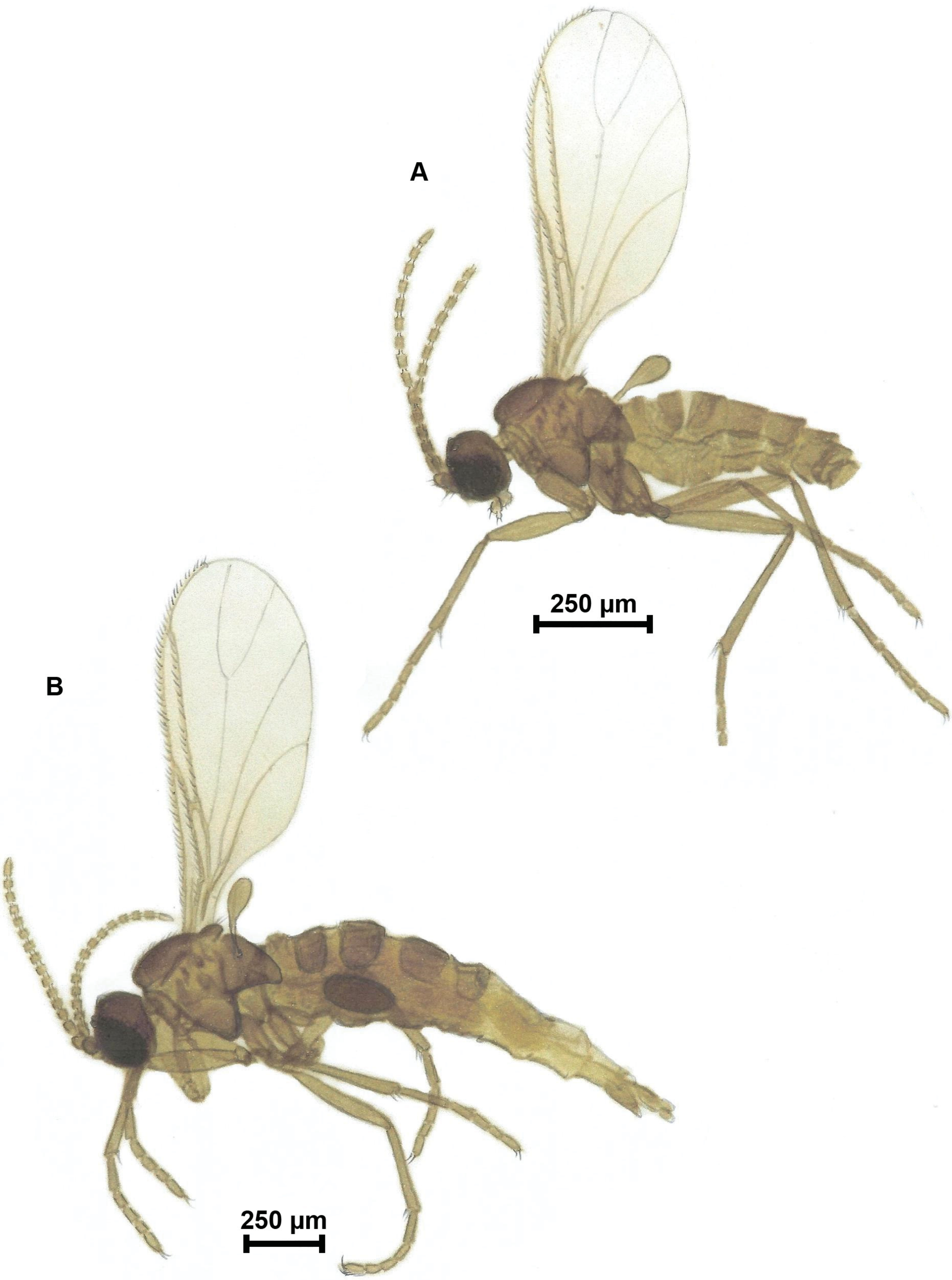

FIGURE 7. *Cosmosciara hartii* (Johannsen, 1912). A. Male (morphotype I). B. Female (morphotype I).

Diagnostic remarks. The species can easily be identified as belonging to *Lycoriella* s. str. because of the following characteristics: a horseshoe-shaped border of the tibial organ on the fore tibia, a 3-segmented palpus with a deep and dark sensory pit on the basal segment, a hypopygium with a few intergonocoxal bristles on the ventral

base, gonostylus with an apical tooth, few spines and a long whiplash hair on the inner side. It differs from the other two pest species by having a rather short gonostylus, widened in the middle and somewhat flattened on the inner side. On the inner side there are 4 rather long hyaline spines located above the whiplash hair. Another good character is the presence of only a few bristles on the membranous basal part of the hypopygium (intergonocoxal space), in contrast to the densely haired intergonocoxal lobe of the other two species.

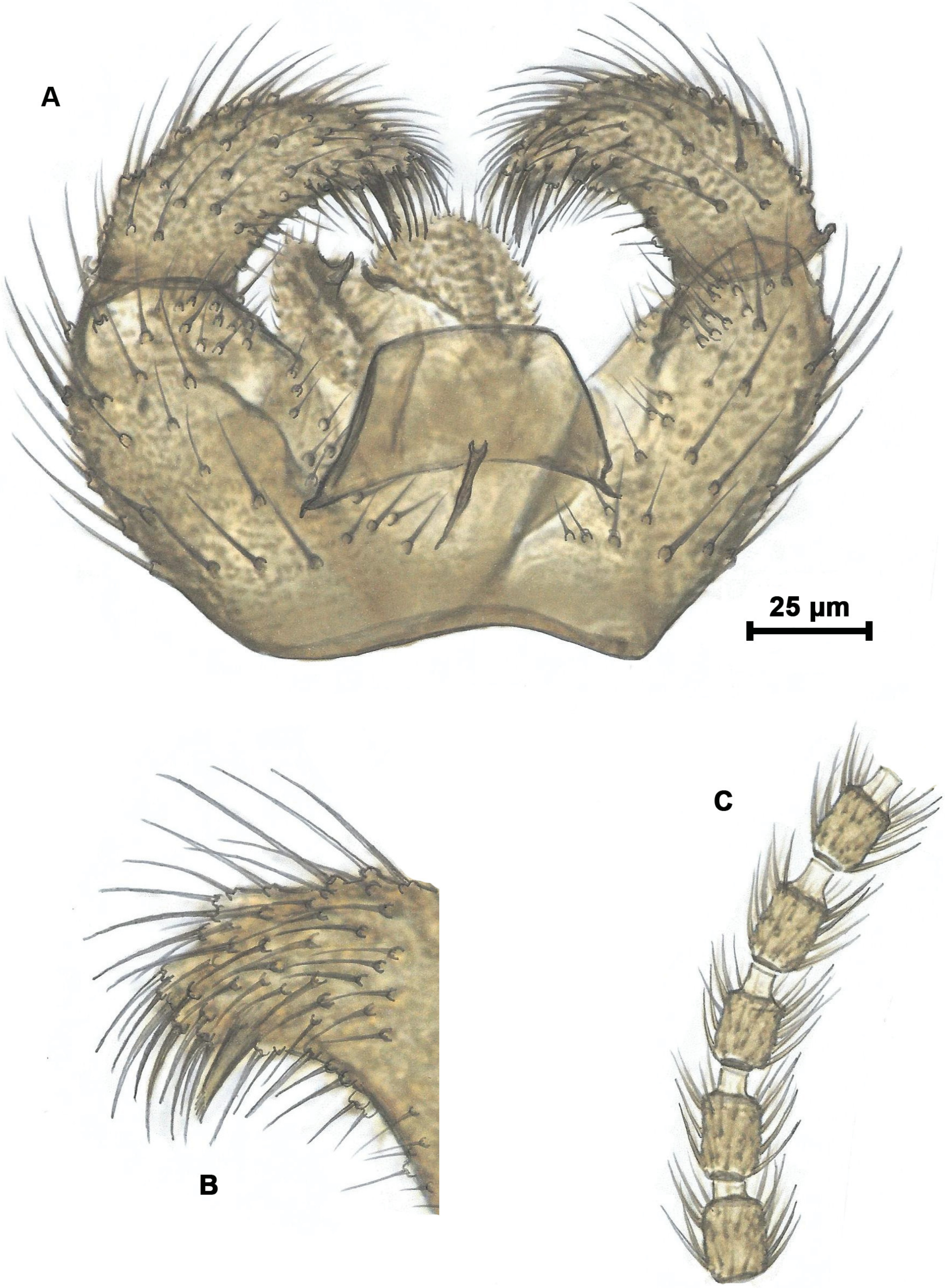

FIGURE 8. *Cosmosciara hartii* (Johannsen, 1912). Male (morphotype I). A. Hypopygium. B. Distal part of gonostylus. C. Flagellomeres 2–6.

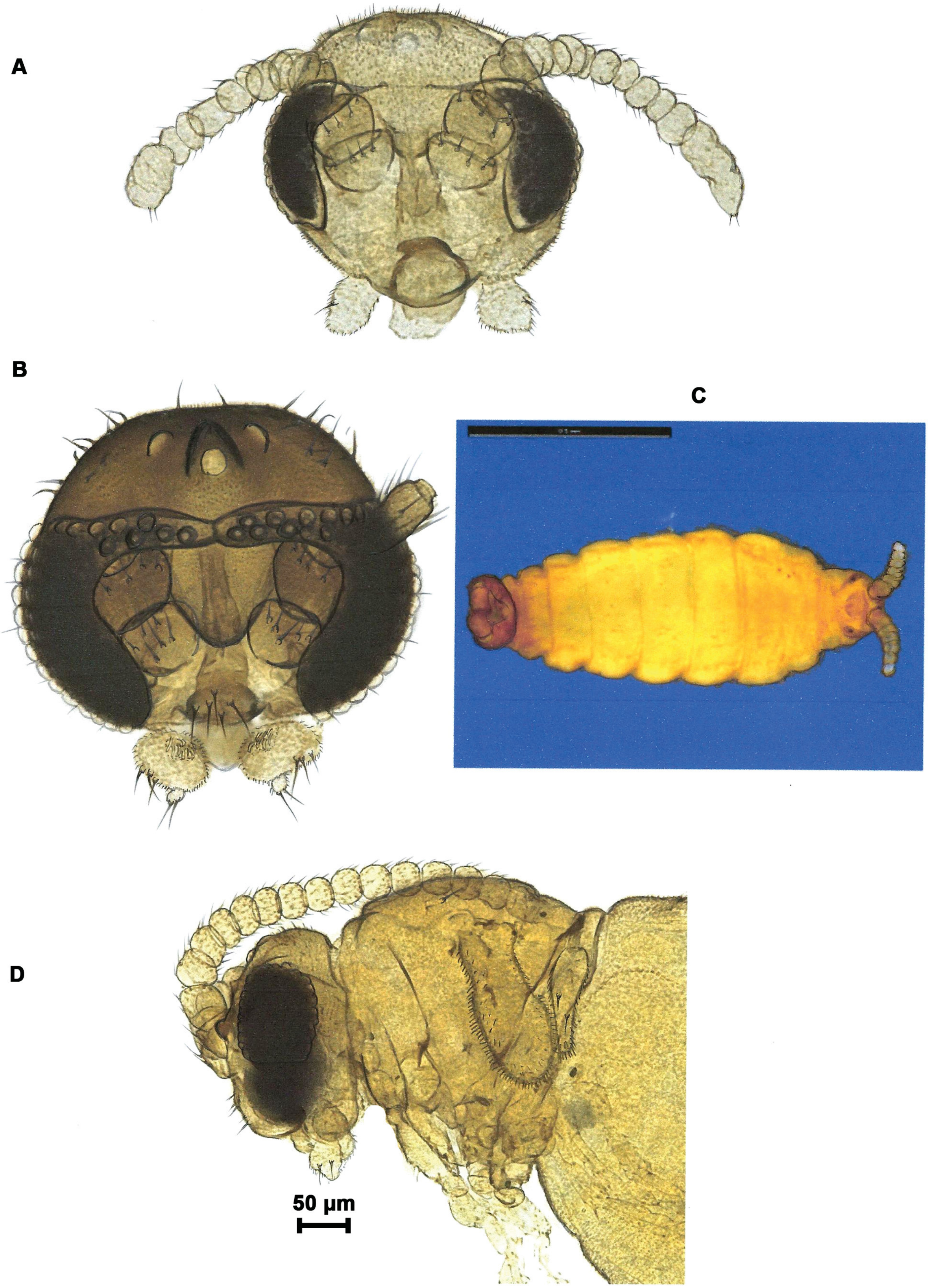

FIGURE 9. *Cosmosciara hartii* (Johannsen, 1912). (A, C and D, morphotype II). A. Head, female (specimen from Hawaii). B. Head, female (morphotype I, from Europe). C. Male (specimen from Fiji). D. Head and thorax of female (specimen from Hawaii).

Economic importance. In the late 1970's *L. sativae* (= *L. agarici*) was reported to cause about 15% crop loss to commercial mushrooms in New South Wales (Loudon 1978). More recently, Shamshad (2010) reported that on an average mushroom farm in Australia the cost of recommended control measures for sciarids accounts for about 0.5% of the value of the crop. In the UK, Freeman (1983) noted that this species had been "reared from birds' nests and rotting vegetables, also recorded around houses, in greenhouses and mushroom houses where it may be a minor pest." Also reported from Russia, attacking mushrooms grown under glass in Leningrad province (Gerbatchevskaya 1963).

Distribution. Holarctic; Australia, Norfolk Island, Subantarctic Islands; Hawaii.

Additional notes. *Lycoriella sativae* was first collected from mushroom beds in Sydney in 1936, according to the material that we have examined. It is interesting to note that protected mushroom production in Australia started in the 1930's, when they were "grown mainly in sheds, cellars and in railway tunnels at Circular Quay, Glenbrook, Lithgow and Picton; under the pylons of Sydney Harbour Bridge; and in old brick kilns at Ryde" (Nair 1978). We found *L. sativae* to be the most common *Lycoriella* species in the BCRI material (see *L. ingenua*—Additional notes).

II. Potential pest species not yet reported from Australia

Bradysia tilicola (Loew, 1850)

(Fig. 10 A–E)

Sciara tilicola Loew, 1850 [Loew (1850): 18].

Common synonyms: *Bradysia amoena* (Winnertz, 1867); *Bradysia caldaria* (Lintner, 1895); *Bradysia coprophila* (Lintner, 1895).

Literature: Winnertz (1867): 114–115 (as *Sciara amoena*); Lintner (1895a): 394–396, figs 4, 5 a–e, plate I, figs 1–4, 8, 9, 11, 11 a (as *Sciara coprophila*); Lintner (1895b): 397–399 (as *Sciara caldaria*); Johannsen (1912): 120, 123, 136–137, plate III, figs 133, 144; Smith-Stocking (1936): 421-443, figs 1–3 (both as *Sciara coprophila*); Lengersdorf (1925): 211, plate VII, fig. 29 (as *Sciara amoena*); Tuomikoski (1960): 129–132; Freeman (1987): 202, fig. 10; Blaschke-Berthold (1988): 347–350, figs 3, 8, 11; Menzel & Mohrig (2000): 147–151, figs 132–133 (all as *Bradysia amoena*); Menzel *et al*. (2006): 63–64; Menzel *et al.* (2013): 286–287; Mohrig *et al*. (2013): 171–172.

Material studied. 3 males, 1980, Melbourne, ex lab. colony, ASCT00053385 (PABM)/53386/53387 (ASCU), leg. A.J. Stocker. The determination is not certain, since males were embedded in an artificial resin which deformed the specimens by shrinking. The wings show a slight aberrant venation in all three specimens which might be caused by artificial rearing in the laboratory culture. The typical macrotrichia on y are present in the specimens. The specimens that we examined were part of a lab colony originally sourced from a laboratory in the USA (A. Stocker, personal communication). We have not seen any collected from the 'wild' yet. Until we do we must regard *B. tilicola* as not recorded in Australia.

B. tilicola is widespread in the Holarctic region. It is common in flower pots, in glasshouses, and has been reared from fungi, tulip and lily bulbs, decaying onions, and young ling seedlings. In open landscapes, it has been found in gardens, farmland, alder carr woodland, moorland, and wetlands including fens, bogs, and sedge beds (Menzel *et al.* 2006). In the southern hemisphere it has been reported from Tristan da Cunha archipelago, where it was introduced by humans.

Diagnostic remarks. The species can easily be identified as belonging to the genus *Bradysia* by the comb-like row of bristles at the apex of the fore tibia, a rather long R_1 and more than 2 bristles on the basal palp segment. It is characterized by the 4th flagellomere with l/w index of 2.5, a deep sensory pit on the basal segment of the palpus, macrotrichia on the x and y wing veins, hypopygium without a basal lobe, gonostylus with a short tooth located dorsally and a dense group of longer apical/subapical spines and a trapezoid tegmen. The macrotrichia on x and y are especially good diagnostic characters.

Economic importance. The species is common in houses with plant pots but rare in greenhouses and mushroom cultures. It is usually a harmless cohabitant and does not cause economic damage to plants.

Distribution. Holarctic. For the southern hemisphere there is only one verified report, from the Tristan da Cunha archipelago (Menzel *et al*., 2013) [the report from New Zealand (*Sciara marcilla* Hutton, 1902) is not certain (Mohrig & Jaschhof 1999: 96)].

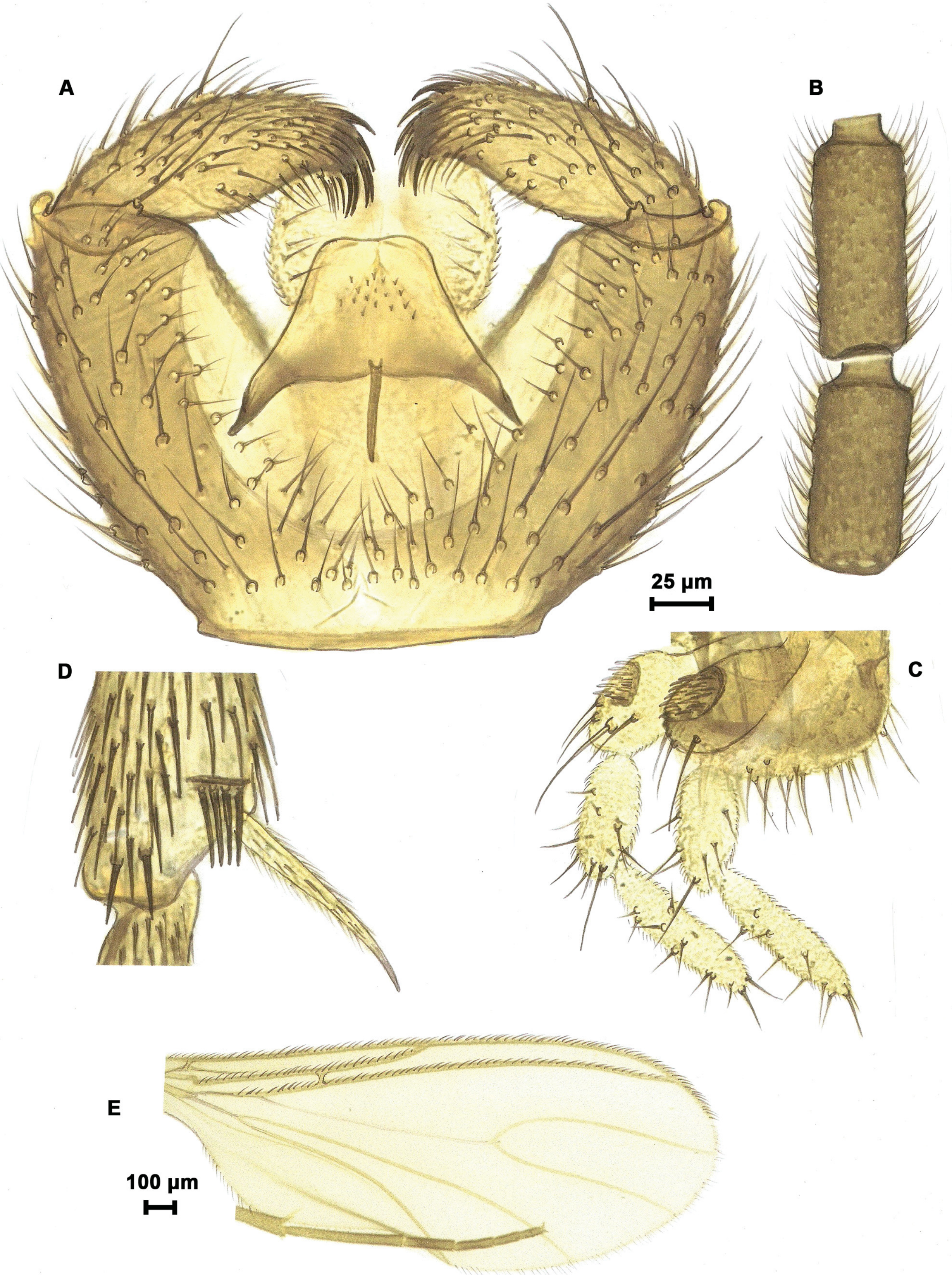

FIGURE 10. *Bradysia tilicola* (Loew, 1850); (specimen from Europe). A. Hypopygium. B. Flagellomeres 4–5. C. Palpus. D. Fore tibia. E. Wing.

***Pnyxia scabiei* (Hopkins, 1895)**
(Figs 11 A–C, 12 A–B)

Epidapus scabiei Hopkins, 1895 [Hopkins (1895): 152–157, fig. 10 a–f].
Common synonym: *Peyerimhoffia subterranea* (Schmitz, 1913).

Literature: Schmitz (1913): 212, figs 1–4 (as *Peyerimhoffia subterranea*); Johannsen (1912): 115, figs 136, 262; Menzel *et al*. (1990): 348–349; Menzel *et al*. (2006): 117; Menzel & Mohrig (2000): 453–455, figs 423–428; Mohrig *et al*. (2013): 225.

The lectotype of *P. scabiei* (Hopkins) was reared from potato tubers in West Virginia, USA, paralectotypes were reared from ordinary potting soil, stable manure, in a mushroom bed in a greenhouse and from seed tubers (Pennsylvania, USA). The species is known in Europe as a pest in glasshouse cucumbers (Germany), and has been reared from rotting narcissus and other bulbs. It has also been recorded damaging potatoes, paeony roots, tomato and cucumber seedlings (United Kingdom) and has also been found in open landscapes (mole holes and ant nests).

Diagnostic remarks. In both sexes the eye bridge is reduced to a sclerotized stripe (without ommatidia), ocelli are present, the antennae are long and the 4th flagellomere has a l/w index of about 3.0, the neck 1/3 of the length of the basal node, a one-segmented "spotlight-like" palpus, apically truncate, with sensillae and a large terminal sensory pit, postpronotum with a few hairs, fore tibia with indistinct bristles, spurs on p_2 and p_3 short, in males wings are shortened differently, the venation is aberrant; females are apterous (wings and halteres absent), scutellum reduced, pleural sclerites more or less regular, hypopygium on ventral base without lobe or bristles, gonostylus apically rounded, with a very short subapical tooth and a fine hyaline spine, tegmen large.

Body length: ca. 1.6 mm.

Economic importance: Recorded as a pest of potted glasshouse cucumber plants in the UK (Speyer 1922; Hussey *et al.* 1969) and in Germany (Mohrig pers. obs.). Sometimes called the "potato scab gnat", and has been reported attacking hothouse cucumbers near Leningrad, potato fields and stores in the Ukraine and noted as a vector of root and tuber rot in vegetable storage cellars (Gerbatchevskaya 1963).

Distribution: Holarctic.

III. Species with uncertain connection to plant or mushroom cultures

***Bradysia pallipes* (Fabricius, 1787)**
(Fig. 13 A)

Tipula pallipes Fabricius, 1787 [Fabricius (1787): 326].
Common synonyms: *Bradysia brunnipes* (Meigen, 1804); *Bradysia prolifica* (Felt, 1898).

Literature: Felt (1898): 226, fig. 8–9 (as *Sciara prolifica*); Meigen (1804): 99 (as *Sciara brunnipes*); Mohrig & Menzel (1993): 271–272, fig. 3; Menzel & Mohrig (2000): 134–137, fig. 127 a (both as *Bradysia brunnipes*); Menzel & Heller (2005): 350–351; Mohrig *et al.* (2013): 168–169.

Material studied. **NEW SOUTH WALES**: 1 male, ix.1936, Sydney, mushroom beds, ASCT00053467, leg. unknown; 1 male, Rydalmere, 21.ii.1978, MV light trap, ASCT00053464; 1 male, 24.x.1979, MV light trap, Rydalmere, ASCT00053463, leg. unknown (all in ASCU).

AUSTRALIAN CAPITAL TERRITORY: 5 males, May 1981, Canberra, infesting CSIRO dung beetle cultures on floor, ASCT00053455-53459, leg. D.H. Colless (53456 in PABM, remainder in ASCU).

Diagnostic remarks. *B. pallipes* is characterised by having macrotrichia on y, long bristles in the middle of the ventral inner-side of the gonocoxites that are directed inwardly, and a circular gonostylus, with short, dense and pelt-like hairs apically and a large apical tooth. The species is a new record for Australia.

Comments: This species is widely distributed in the Palaearctic region and is locally abundant there. In the southern hemisphere, it occurs in New Zealand (Mohrig & Jaschhof 1999). *Bradysia pallipes* does not appear to be common in Australia based on the comparatively few specimens that we have examined, however like *L. sativae* it has been present since the early days of protected mushroom cultivation.

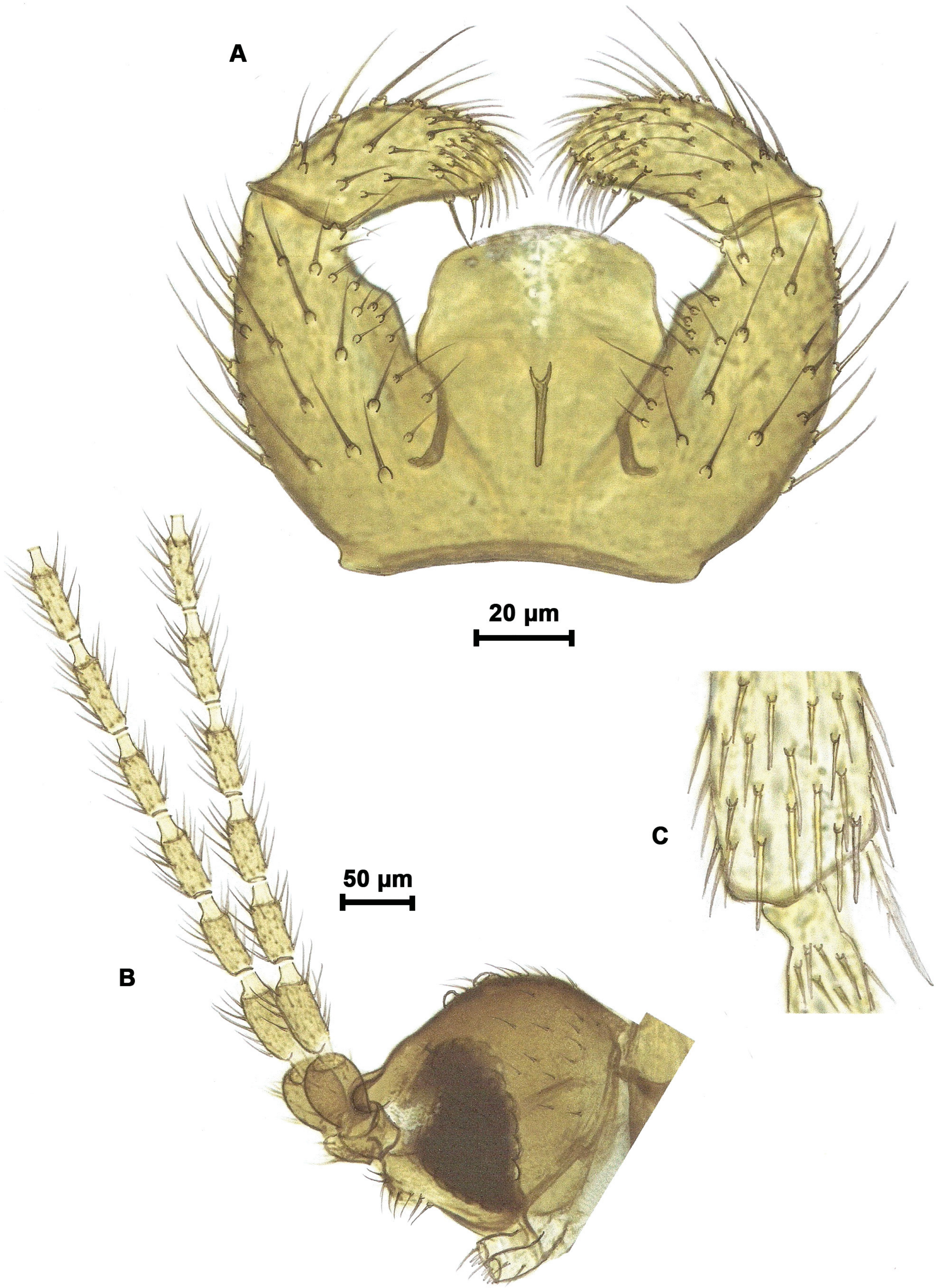

FIGURE 11. *Pnyxia scabiei* (Hopkins, 1895). A. Hypopygium. B. Head with basal segments of antenna (male). C. Fore tibia.

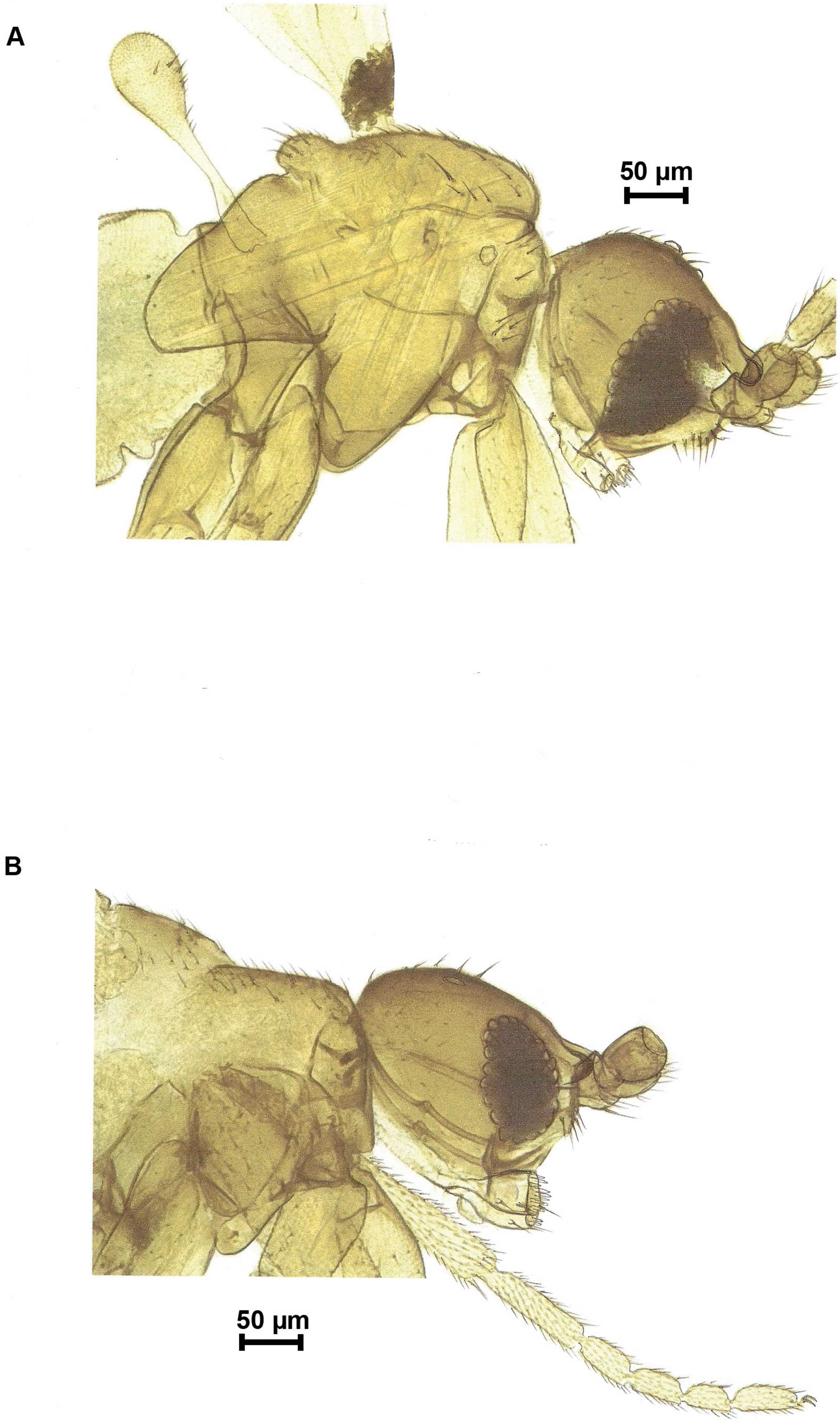

FIGURE 12. *Pnyxia scabiei* (Hopkins, 1895). A. Head and thorax (male). B. Head and thorax (female).

Economic importance. Reported to attack cucumbers under glass, and mushrooms in the former USSR (Gerbatchevskaya 1963). Also reported as a mushroom pest by Hussey *et al*. (1969). Felt (1898) described it as being quite common in greenhouses in Massachusetts, USA. We believe that *B. pallipes* is a relatively uncommon species in Australia and not likely to be a true pest.

Distribution. Cosmopolitan.

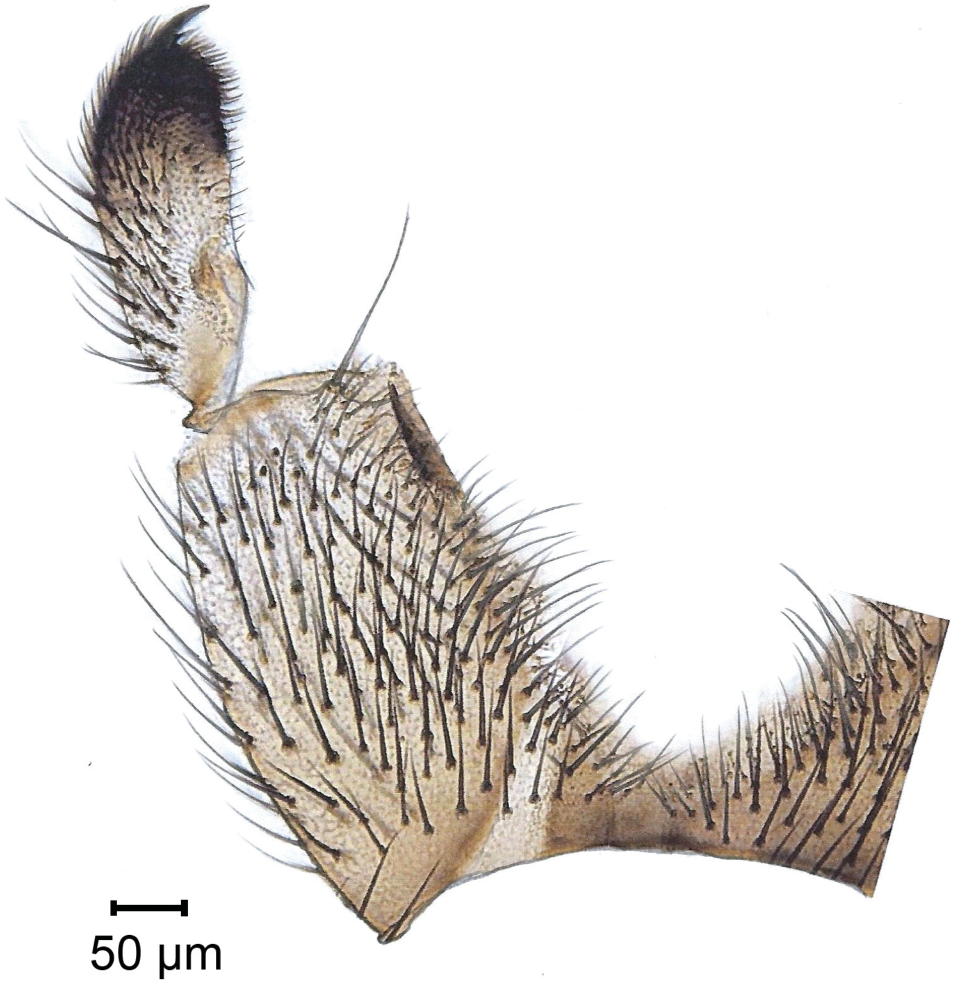

FIGURE 13. *Bradysia pallipes* (Fabricius, 1787); (specimen from Australia). A. Hypopygium (left half in ventral view).

Bradysia strenua (Winnertz, 1867)
(Fig. 16 A–D)

Sciara strenua Winnertz, 1867 [Winnertz (1867): 100]
= ***Bradysia watsoni* Colless, 1962 syn. n.** [Colless (1962): 955–957, fig. 1 a–g]

Literature: Edwards (1925): 540; Edwards (1938): 201 (both as *Sciara varians*); Laurence (1994): 118; Weber *et al.* (1995): 94–96; Laurence (1996): 87 (all as *Bradysia brunnipes*); Mohrig & Menzel (1993): 283–285, fig. 17 a–d; Menzel (1998): 20; Menzel & Mohrig (2000): 142–143.

Material studied. **NEW SOUTH WALES**: 1 male, November 1978, Armidale, in soil and bulbs, ASCT00054275, leg. unknown (ASCU).

TASMANIA (MACQUARIE ISLAND): 2 males (paratypes), 23 March 1961, Langdon Point, leg. K. Watson, M/61/In/242, ANIC Database No. 29, 006589 (PABM) and 006590 (PWMP). 2 males (paratypes), 19 January 1961, Langdon Point, leg. K. Watson, M/61/In/48, ANIC Database No. 29, 006592 (ANIC) and 006593 (PABM). 1 male, 27 October 2009, Australia, TAS, Macquarie Island, Razorback Ridge, M&P004SCBT, leg. P.

Hudson & M. Potter, *Stilbocarpa* beating (SAMA). 1 female, 2015, (Barcode of Life MACQSCI; dx.doi.org/10.5883/DS-SCIAMACQ; GenBank accession MG647919) 54.49384 158.94148, pitfall trap, *Poa foliosa* (tussock), leg. M. Houghton (PABM).

Comments: Colless (1962) described *B. watsoni* from Macquarie Island, a subantarctic island located in the southwest Pacific Ocean about half way between New Zealand and Antarctica. In his paper, Colless noted that "the possibility cannot be entirely excluded, that the Macquarie I. species is an immigrant, already described in another country. However, in the literature available to me, I can find no definite evidence that this is so." The type and a series of paratypes are deposited in the Australian National Insect Collection in Canberra. The male holotype is mounted in a card stub so detailed microscopic examination of it was difficult. However, we were able to select 3 male paratypes from the pinned material and slide mount them in Canada balsam. All 3 paratypes and a male specimen collected from the island in 2009 are identical to the figures given by Colless (1962). In the ASCU material we found one male specimen that was collected in 1978 from "soil and bulbs" in Armidale, New South Wales. This is the first Australian mainland record. All of these specimens are morphologically identical to *Bradysia strenua* from Europe. We also examined a female specimen collected from a pitfall trap on Macquarie Island in 2015 and found a 99–100% match for *B. strenua* via sequencing and analysis of the cytochrome oxidase 1 (CO1) gene. The species may have been introduced to Macquarie Island in the 19th or early 20th century, when seal harvesting gangs were exploiting the island. Adults have been recorded on the island throughout the year; most commonly walking or flying under Macquarie Island cabbage (*Stilbocarpa polaris*), but they have also been found in tall grasslands, and on *Poa annua*, *Leptinella plumosa* and *Pleurophyllium hookeri* (van Klinken & Greenslade 2006). In Europe, *B. strenua* is free living and rather common in open fields. It is seldomly found in forests or caves. The larvae are herbivorous, perhaps mining in leaves, and they have been reared from decaying narcissus bulbs, potatoes, a mole nest, angelica root, and old ragwort stems (Menzel *et al*. 2006).

Diagnostic remarks. The species is characterised by an elongate gonostylus with a rounded apex, a strong apical tooth and apically rounded tegmen with a small longer than wide area of teeth and short hairs on the inner ventral margin of the gonocoxites (in this latter character it differs from the similar species *B. pallipes*).

Economic importance. Not known to mass breed or to be a pest so unlikely to be of economic importance.

Distribution. Holarctic: Canada, Germany, Norway, Poland, Spain, United Kingdom; Australia (new record): New South Wales, Tasmania (Macquarie Island).

Corynoptera concinna (Winnertz, 1867)

(Fig. 15 A–C)

Sciara concinna Winnertz, 1867 [Winnertz (1867): 150–151].
Common synonym: *Corynoptera semiconcinna* Mohrig & Krisvosheina, 1985.

Literature: Lengersdorf (1925): 212, Figs 7, 32 (as *Sciara concinna*); Lengersdorf (1941): 50, Plate 2, Fig. 15 (as *Sciara concinna*); Lengersdorf (1928–30): 47, Plate 3, Fig. 59 (as *Lycoria* (*Neosciara*) *concinna*); Leclercq (1944): 108 (as *Neosciara concinna*); Mohrig *et al*. (1985): 304–305, Fig. 6 a–c (as *Corynoptera semiconcinna*); Tuomikoski (1959): 165; Mohrig (1993): 49–50, Fig 1 a–d; Rudzinski (1996): 113; Menzel *et al.* (2006): 70; Menzel & Mohrig (2000): 244, fig. 196.

Material studied. VICTORIA: Filmont drive, Werribee. 8 males, xi.2015, yellow pan trap in house near *Phalaenopsis*/banana plants in pots, #87A, leg. L. Watson (2 in ANIC, 2 in PABM, 3 in PWMP, 1 in SDEI).

Diagnostic remarks. The species is characterized by 4th flagellomere 2.5–3.2 times as long as wide, gonostylus with one short robust spine in the upper quarter in an excavation, the spine pointing inwards and downwards and on a high socket, angle of wing-like bulge on inner side near spine almost right-angled, apex of gonostylus distinctly tapered and narrowly rounded, tegmen widely rounded and without central sclerotized ridges, aedeagus moderately long and narrow.

Body length: 2.3 mm.

Economic importance. The species was caught repeatedly in yellow pan traps placed near pot plants in a house in Victoria. In Germany we are aware of a case of mass breeding in pots with *Primula acaulis* plants imported from the Netherlands (pers. comm., F. Menzel). However, it is not regarded as a serious pest.

Distribution. Europe. Australia (Victoria), new record.

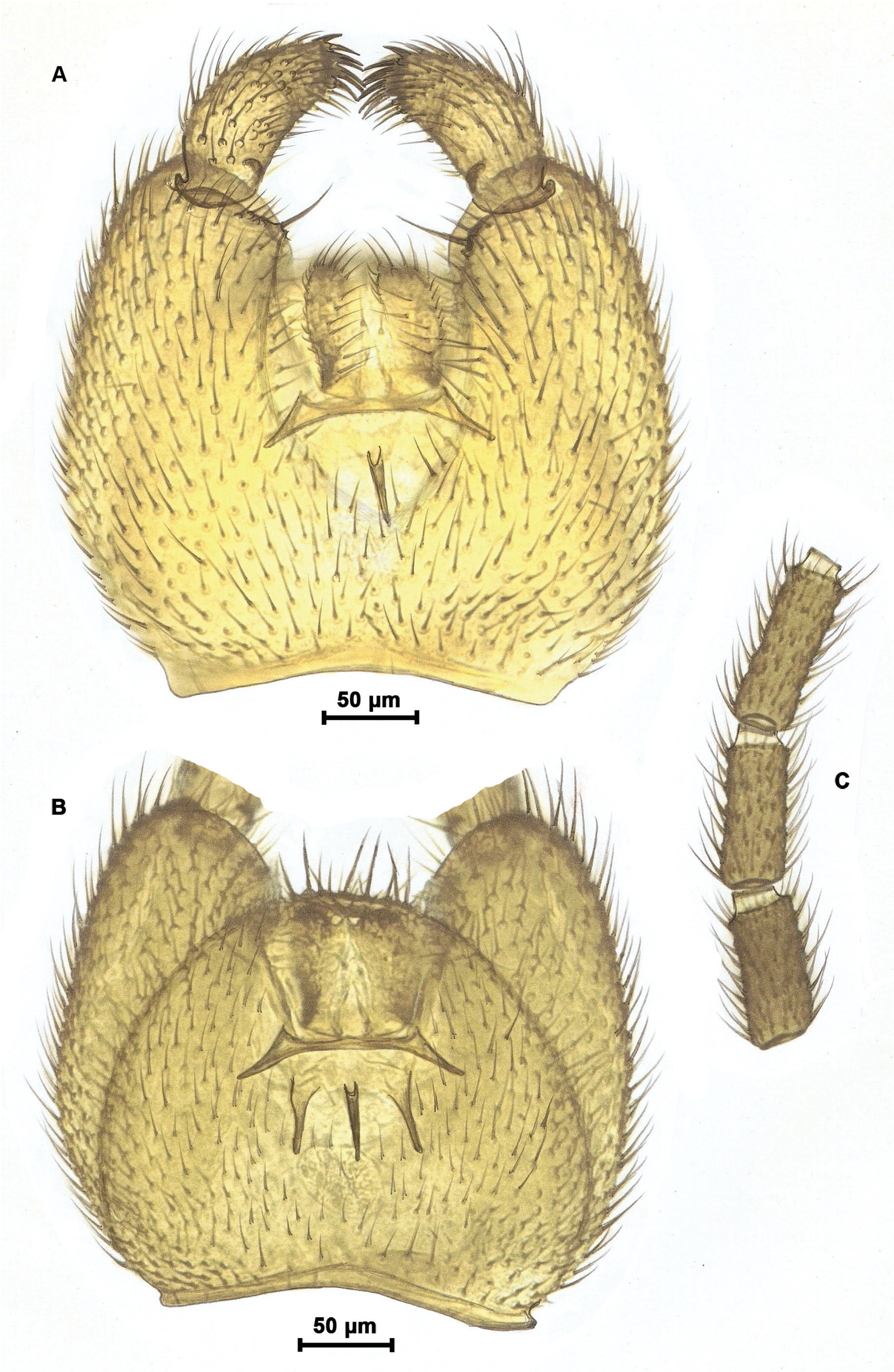

FIGURE 14. *Bradysia spatitergum* (Hardy, 1956). A. Hypopygium, ventral side. B. Hypopygium, dorsal side. C. Flagellomeres 3–5.

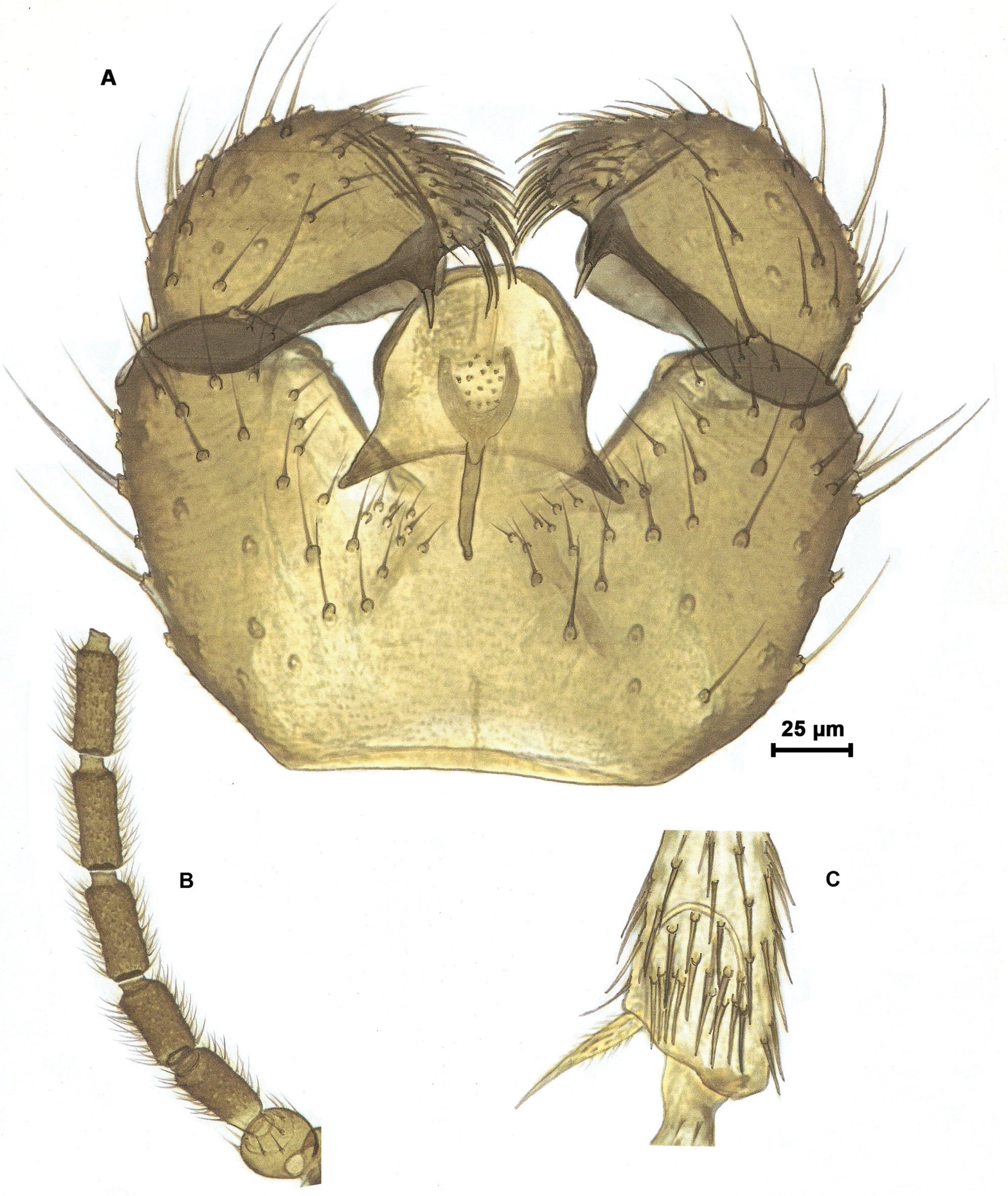

FIGURE 15. *Corynoptera concinna* (Winnertz, 1867). A. Hypopygium. B. Basal segments of antenna. C. Fore tibia.

Hyperlasion aliens Mohrig, 2004
(Fig. 18A–C)

Hyperlasion aliens Mohrig, 2004 [Mohrig (2004): 159–160, fig. 27 a–f].

Literature: Menzel & Smith (2009): 38–40, figs 39–41.

Material studied. **TASMANIA**: 1 male, 31.viii.1988, Australia, Tasmania, Devonport, 103594, pot plant, indoors, leg. L. Hill (TAIC).

Diagnostic remarks. This species is characterized by the small size, 2 subapical pairs of spines on the gonostylus, one-segmented palps (without an apical pit of sensillae), very short, pin-shaped tibial spurs, and wing with both a reduced anal field and CuA stem.

Body length: 1 mm.

Economic importance. Not known to be a pest, so it is unlikely to be of economic importance.

Distribution. Papua New Guinea; Seychelles; Australia (Tasmania): new record. [Note: it is uncertain if this species is established in Tasmania as there is just one record].

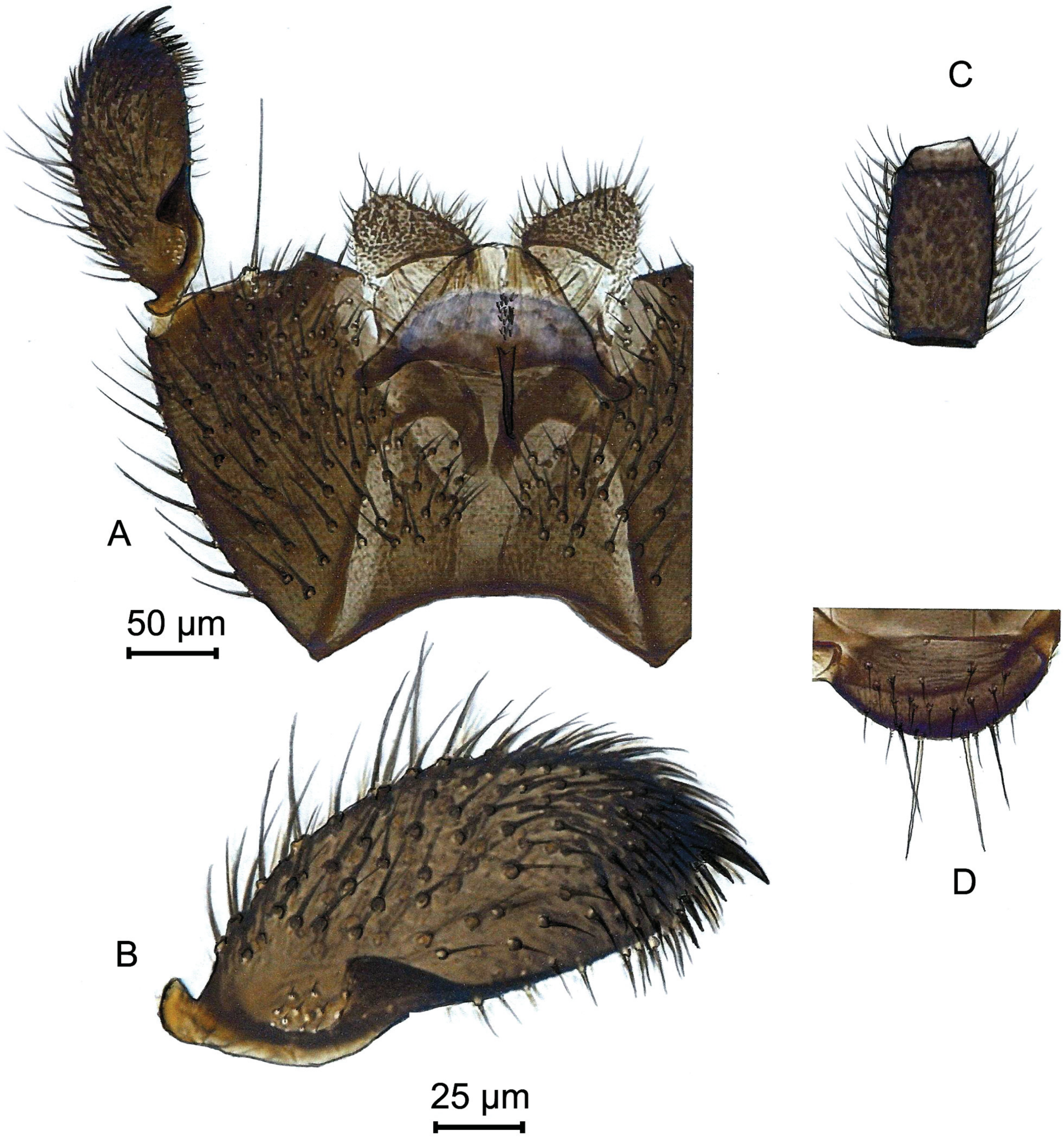

FIGURE 16. *Bradysia strenua* (Winnertz, 1867). A. Left side of the hypopygium in ventral view. B. Gonostylus. C. 4th flagellomere. D. Scutellum.

IV. Biosecurity interceptions

The cosmopolitan pest *Bradysia impatiens* is most frequently encountered during biosecurity inspections. However, we found two other species amongst the intercepted material, which are worthy of further elaboration here.

Bradysia spatitergum (Hardy, 1956)

(Fig. 14 A–C)

Sciara (*Lycoriella*) *spatitergum* Hardy, 1956 [Hardy (1956): 85, fig. 10 a–c].

Literature: Steffan (1968): 515; Steffan (1973a): 356; Menzel & Smith (2009): 28–29, figs 1.11–13; Mohrig (2016): 24–25, fig. 28 a–e.

Material studied: 1 male, 13.v.2014, Australia, Melbourne, biosecurity intercept (Bottle 223993), on *Ficus microcarpa* plants ex China, leg. A. Czelusta (PABM).

The species was described from the Hawaiian Islands. Hardy (1960) reported the species from rotting sugar cane, rotting sweet potatoes and coffee grounds. Steffan (1968) collected this species in a banana plantation and on flowers in Brazil and Panama, Menzel & Smith (2009) from the Seychelles Islands and Mohrig (2016) from Papua New Guinea (Malaise trap) in an open landscape.

Diagnostic remarks. The species is characterized by extraordinarily large gonocoxites and a very large IX tergite, both uniformly short haired. The gonostyli are small in comparison to the large gonocoxites. It is closely related to *B. megahypopygialis* Mohrig, 2016 and *B. venusta* Mohrig, 2016 from Papua New Guinea. *Bradysia spatitergum* differs from those two species by the presence of a distinct, dorsally inserted claw-like tooth on the apex of the gonostylus.

Economic importance. According to the literature it is not of any economic importance. It has not been detected in greenhouses or mushroom farms and is not known to breed en masse, but it is found in association with rotting plant material in the vicinity of farmland and has been distributed by humans.

Distribution. Widely distributed within the southern hemisphere from Hawaii, Central and South America to Papua New Guinea. Also recorded from Zimbabwe, Madagascar, India and the Seychelles (Mohrig 2016). The detection of this species during the on-arrival biosecurity inspection of a consignment of plants imported from China suggests that it is present in China too but this needs to be confirmed.

Scatopsciara atomaria (Zetterstedt, 1851)

(Fig. 17 A–D)

Sciara atomaria Zetterstedt, 1851 [Zetterstedt (1851): 3761–3762]
Common synonym: *Scatopsciara vivida* (Winnertz, 1867)

Literature: Lengersdorf (1928–1930): 58, plate 4, fig. 87 (as *Lycoria vivida*). Frey (1948): 70, 87, plate 20, fig. 120; Tuomikoski (1960): 151–153 (all as *Scaptosciara vivida*); Menzel & Mohrig (2000): 494–496, figs 458–463; Mohrig *et al*. (2013): 235–237.

Material studied: 1 male, 1.xi.2007, Australia, Sydney, biosecurity intercept (Bottle 130376), on *Paeonia* plants ex Canada, leg. M. Coleman (PABM).

Diagnostic remarks. The species is characterised by sparse hairs on the flagellomeres, with a few stronger spear-like bristles among the hairs; short 3-segmented palpi with a sensory pit on the basal segment; wings with a very short R_1; apex of the hind tibia with only one spur; and the gonostylus short and curved, with a long apical tooth and 3–5 somewhat shorter subapical spines.

Economic importance. A ubiquitous and common species, particularly in areas of anthropogenic influence (Mohrig *et al*. 2013), but not known to be a pest.

Distribution. Holarctic. Also distributed in Central America.

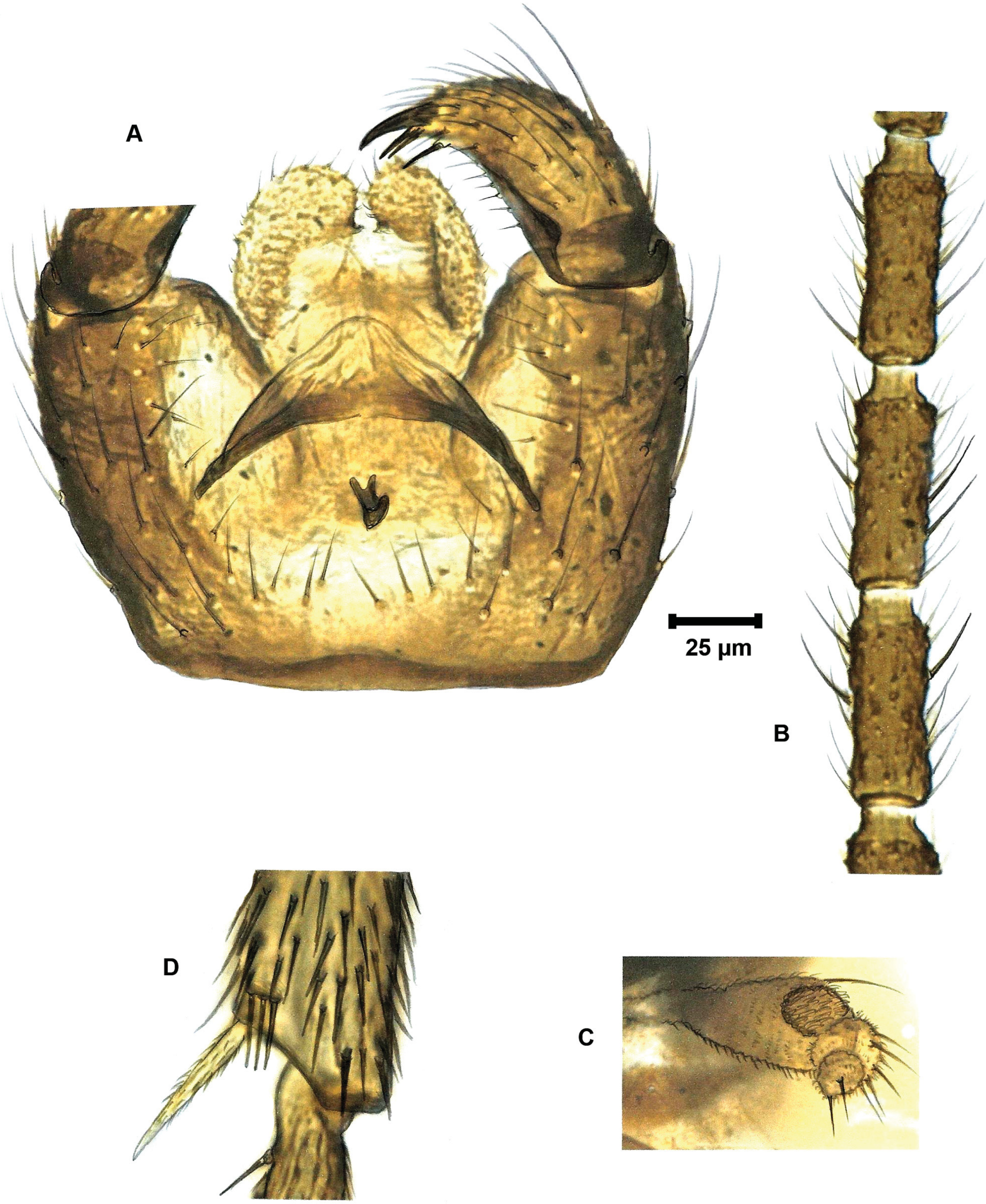

FIGURE 17. *Scatopsciara atomaria* (Zetterstedt, 1851). A. Hypopygium. B. Flagellomeres 4–6. C. Palpus. D. Fore tibia.

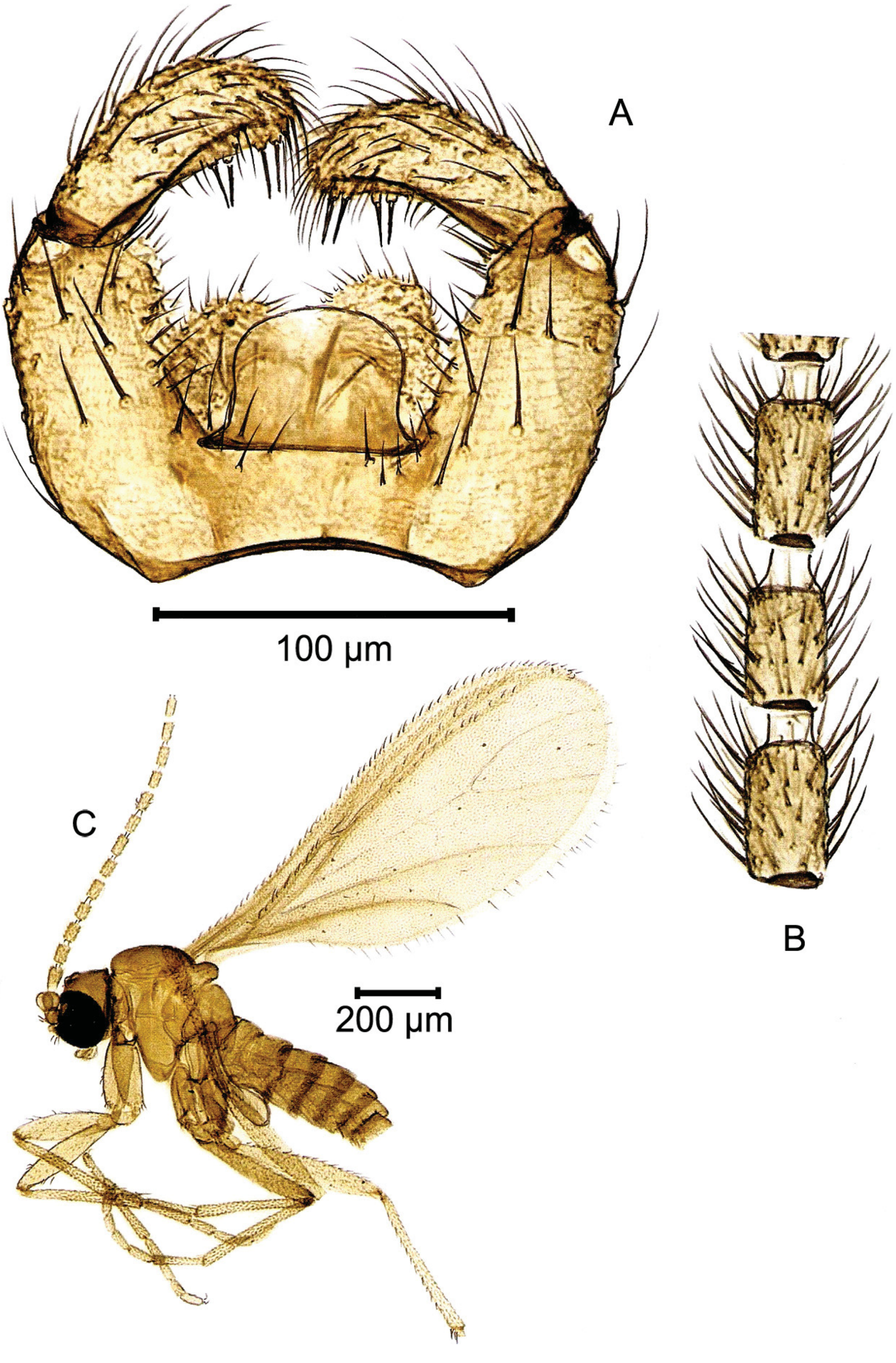

FIGURE 18. *Hyperlasion aliens* Mohrig, 2004 (specimen from Papua New Guinea). A. Hypopygium. B. Flagellomere 3–5. C. Male.

Species list
Bold = valid name

agraria (Felt, 1898), *Lycoriella*
aliens Mohrig (2004), *Hyperlasion*
atomaria (Zetterstedt, 1851), *Scatopsciara*
auberti Séguy (1940), **syn. n.** to *L. sativae* (Johannsen, 1912)
concinna (Winnertz, 1867), *Corynoptera*
hartii (Johannsen, 1912), *Cosmosciara* **comb. n.**
impatiens (Johannsen, 1912), *Bradysia*
ingenua (Dufour, 1839), *Lycoriella*
jeanneli Séguy (1940), **syn. n.** to *L. sativae* (Johannsen, 1912)
ocellaris (Comstock, 1882), *Bradysia*
pallipes (Fabricius, 1787), *Bradysia*
perniciosa Edwards, 1922, **syn. n.** to *Co. hartii* (Johannsen, 1912)
sativae (Johannsen, 1912), *Lycoriella*
scabiei (Hopkins, 1895), *Pnyxia*
solispina Hardy (1956), **syn. n.** to *L. sativae* (Johannsen, 1912)
spatitergum (Hardy, 1956), *Bradysia*
strenua (Winnertz, 1867), *Bradysia*
tilicola (Loew, 1850), *Bradysia*
watsoni Colless (1962), **syn. n.** to *B. strenua* (Winnertz, 1867)
womersleyi Séguy (1940), **syn. n.** to *L. ingenua* (Dufour, 1839)

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